Final Draft Report

Evaluation of Sand Return Option for Buckman Diversion Project, NM

Submitted to

Las Campanas Santa Fe New Mexico

November 2002

CH2MHILL

Contents

Contents, continued

Contents, continued

Acronyms

ac-ft/yr	acre-feet per year
BLM	Bureau of Land Management
cfs	cubic feet per second
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
mgd	million gallons per day
mm	millimeter
mg/L	milligrams per liter
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
NTUs	nephelometric turbidity units
SJC	San Juan-Chama
TSS	total suspended solids
USFS	U.S. Forest Service
USGS	U.S. Geological Survey

Executive Summary

The Buckman river diversion project, currently in planning by a group (Proponents) comprising the City of Santa Fe (City), the County of Santa Fe (County), and Las Campanas Santa Fe (Las Campanas), is intended to provide municipal/industrial water supply peak demands through the year 2010 for the City, County, and all of Las Campanas demands (about 1,800 acre-feet per year [ac-ft/yr]) through final buildout. The project will utilize primarily imported San Juan-Chama (SJC) water and smaller quantities of 'non-SJC' Rio Grande water rights held by the County and Las Campanas.

The proposed Buckman diversion facility would be located on the east bank of the Rio Grande near the terminus of Buckman Road at the riverfront. The facility would include a screened river intake , low-head pump station, belowgrade electrical and control building, and a sediment removal pond (or mechanical sediment removal facility) located several thousand feet upgradient and southeast of the Rio Grande adjacent to Buckman Road. The intake facility is estimated to require a hydraulic capacity of about 32 cubic feet per second (cfs) based on an estimated peak water demand of about 28 cfs plus up to about 4 cfs for 'overpumpage' of carriage water. The carriage water would be used for returning removed sand to the river just below the intake facility. Plans are to remove all sand-sized material >0.25 millimeter (mm) in diameter to minimize potential damage to high-head pumps and conveyance piping over the 1,500-foot elevation gain, 15-mile± route to the proposed new joint City/County water treatment plant near the Santa Fe Municipal Recreation Complex and to Las Campanas.

Evaluation of the likely sequence of project water demands (highest demands in June and July) and seasonal river flows suggests that peak demands will not be coincident with lowest river flows. Moreover, analysis of U. S. Geological Survey (USGS) hydrologic records for the Otowi gage (4 miles upstream of Buckman) indicates that there is a direct relationship between river flows and suspended sediment concentrations; and that, on average, the >0.25-mm sand fraction makes up about 12 percent of the total sediment concentration in the river.

A series of mass balance calculations suggests that removal of the > 0.25-mm sand-sized materials and return to the river below the diversion will cause only slight increases in downstream suspended sediment concentrations – generally less than 1 percent, and under worst-case conditions, less than 3 percent. Expected effects on turbidity levels are also minimal in terms of upstream to downstream increases.

Based on the results of the evaluation presented in this document, the Proponents are respectively requesting that EPA consider an application for a National Pollutant Discharge Elimination System (NPDES) permit to allow the proposed sand return to the Rio Grande as a basis for operation of the Buckman diversion facility.

Background

The Buckman river diversion project, currently in planning by a group (Proponents) comprising the City of Santa Fe (City), the County of Santa Fe (County), and Las Campanas Santa Fe (Las Campanas), is intended to provide municipal/industrial water supply to meet critical water needs in the Santa Fe area. The project is intended to meet peak demands through the year 2010 for the City, County, and all of Las Campanas demands (about 1,800 acre-feet per year [ac-ft/yr]) through final buildout. The project will utilize primarily imported San Juan-Chama (SJC) water and smaller quantities of 'non-SJC' Rio Grande water rights held by the County and Las Campanas.

Considerable preliminary engineering, feasibility studies, and hydrologic evaluations of water supply alternatives have been undertaken for the various parties by CDM (October 2001; September 2002) and CH2M HILL (October 2001). This work has led to the selection of a river intake on U.S. Forest Service (USFS) land at Buckman as the preferred alternative for diverting water from the river for meeting the needs of the project. With USFS and the Bureau of Land Management (BLM) as lead Federal agencies, an Environmental Impact Statement (EIS) is currently (November 2002) underway to evaluate the potential impacts of the proposed project.

The proposed Buckman diversion facility would be located on the east bank of the Rio Grande just downstream of the terminus of Buckman Road at the riverfront (Figures 1 and 2). As presently envisioned and shown in Figure 3, the facility would include a screened river intake (stainless steel fish screen with approximate 2.0 millimeter [mm] openings), low-head pump station, belowgrade electrical and control building, and a sediment removal pond (or mechanical sediment removal facility) located on a terrace some 1,500 feet southeast of the Rio Grande, adjacent to Buckman Road. The intake facility is estimated to require a hydraulic capacity of about 32 cubic feet per second (cfs) based on an estimated peak water demand of about 28 cfs plus up to about 4 cfs for 'overpumpage' of carriage water. The carriage water would be used for returning removed sand to the river just below the intake facility. Plans are to remove all sand-sized material >0.25 mm in diameter to minimize potential damage to high-head pumps and conveyance piping over the 1,500-foot elevation gain, 15-mile± route to the proposed new joint City/County water treatment plant near the Santa Fe Municipal Recreation Complex and to Las Campanas.

A summary of the estimated peak demands required to be met from the Buckman diversion facility are provided in Table 1. Note that the peak demands assume a drought with no water available from the Santa Fe Canyon surface supply or from the Buckman wellfield.

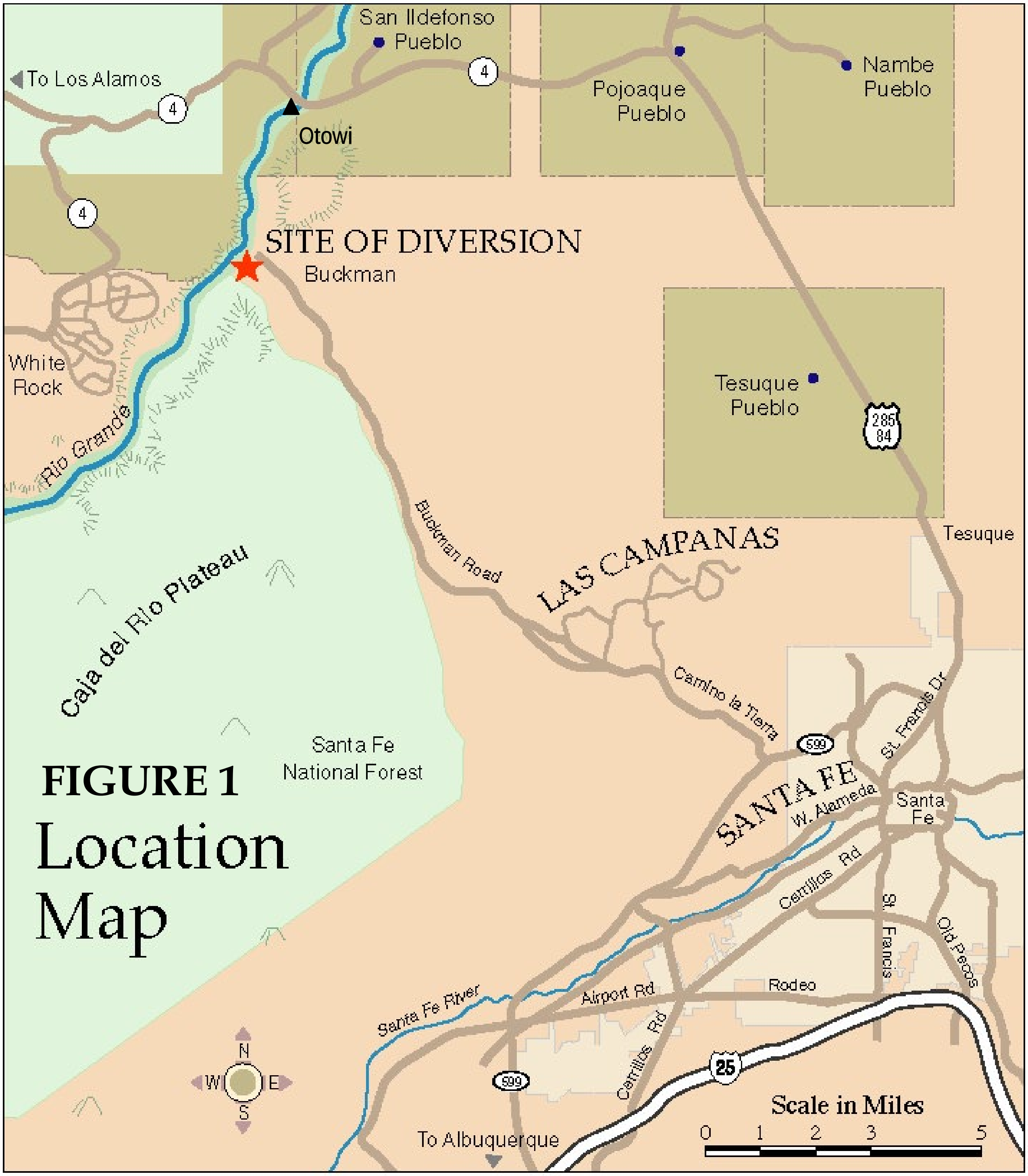


FIGURE 1

Location Map

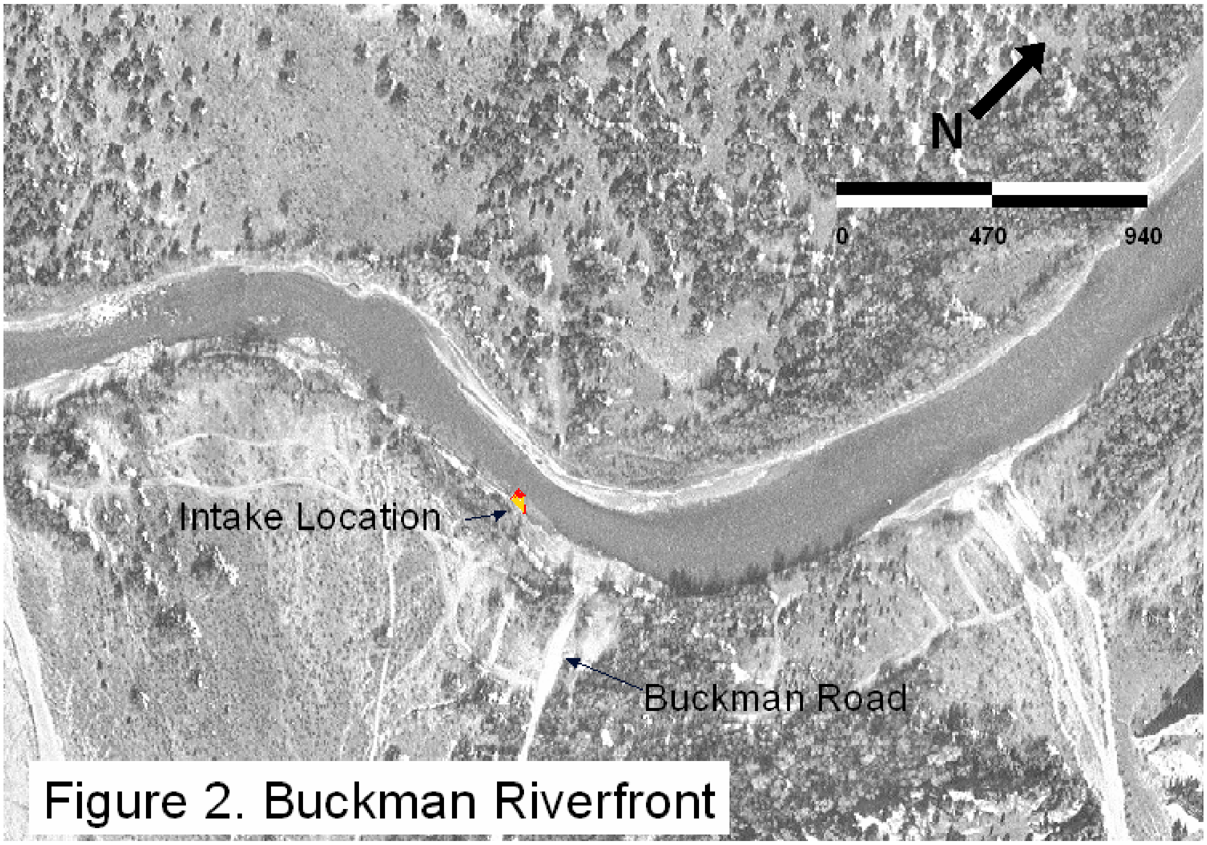


Figure 2. Buckman Riverfront

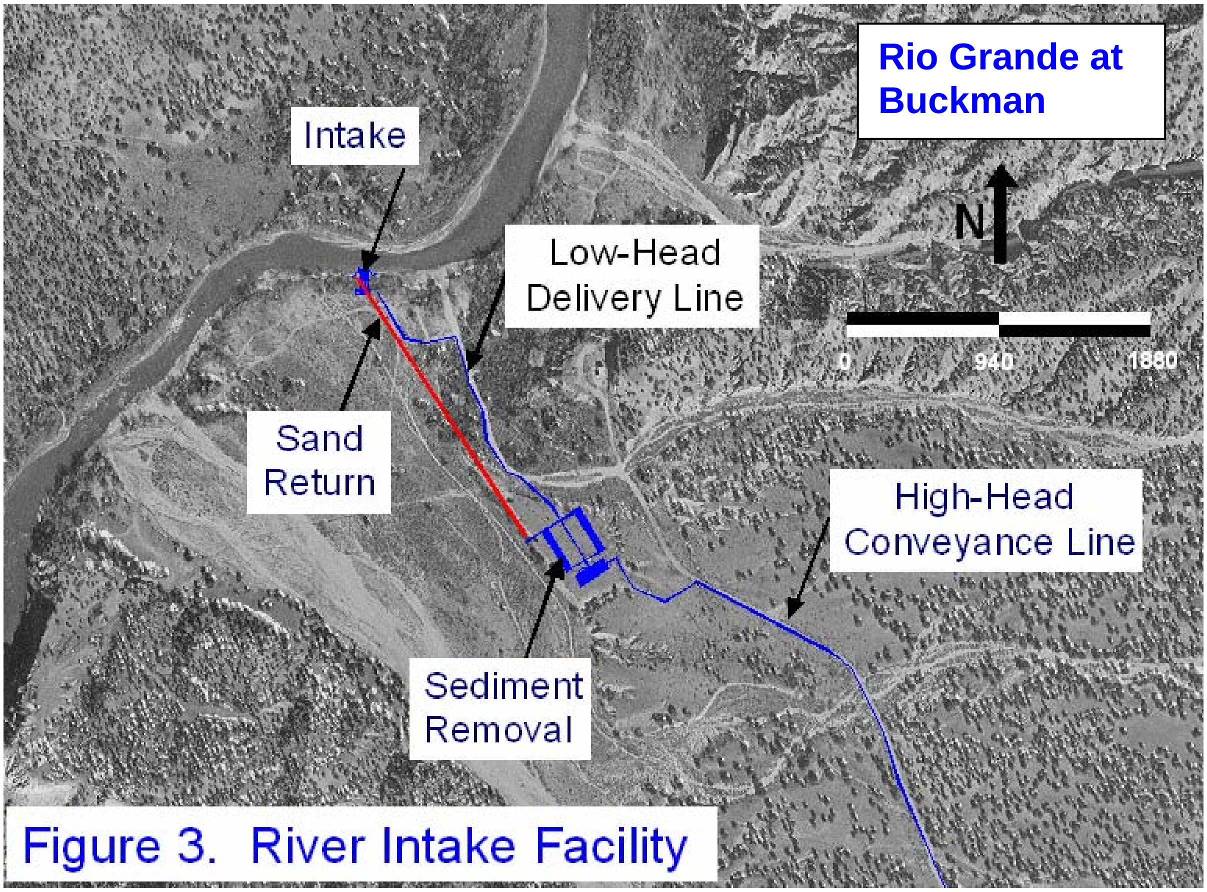


Figure 3. River Intake Facility

Table 1. Estimated 2010 Maximum Annual and 2010 Peak-Day Drought Year Demands for the Buckman Diversion Project

Water User	Annual Demand (ac-ft/yr)	Peak Day Demand (mgd)	Peak Day Demand (cfs)
Santa Fe City/County	6,930	15.0	23.2
Las Campanas	1,800	3.2	5.0
Total	8,730	18.2	28.2
Notes: mgd = million gallons per day. cfs = cubic feet per second.			

Month	Percentage of Peak-Day Demand in Stated Month[a]	Peak-Day Demand[b] (mgd)	Peak-Day Demand[b] (cfs)
January	0.40	7.3	11.3
February	.45	8.2	12.7
March	.50	9.1	14.1
April	.65	11.8	18.2
May	.85	15.4	23.8
June	1.00	18.2	28.2
July	.93	16.9	26.1
August	.85	15.4	23.8
September	.80	14.6	22.6
October	.70	12.7	19.6
November	.50	9.1	14.1
December	.40	7.3	11.3

[a] Estimated from recent records provided by City of Santa Fe.

[b] It is unlikely that peak-day demands listed would occur in consecutive months. Values presented in this table are estimates of the highest probable use of the diversion in any given month.

Purpose and Scope

The primary purpose of this report is to summarize the estimated effects of the proposed Buckman diversion operation on the sediment regime of the Rio Grande in the Buckman area. Of particular interest is the effect of the proposed sand return from the sediment removal facility on the concentration of total suspended sediment and turbidity in the river just downstream of the intake. It is the desire of the Proponents of the Buckman project to utilize the results presented in this report as the basis for a National Pollutant Discharge Elimination System (NPDES) permit from the U.S. Environmental Protection Agency (EPA) for the proposed sand return operation.

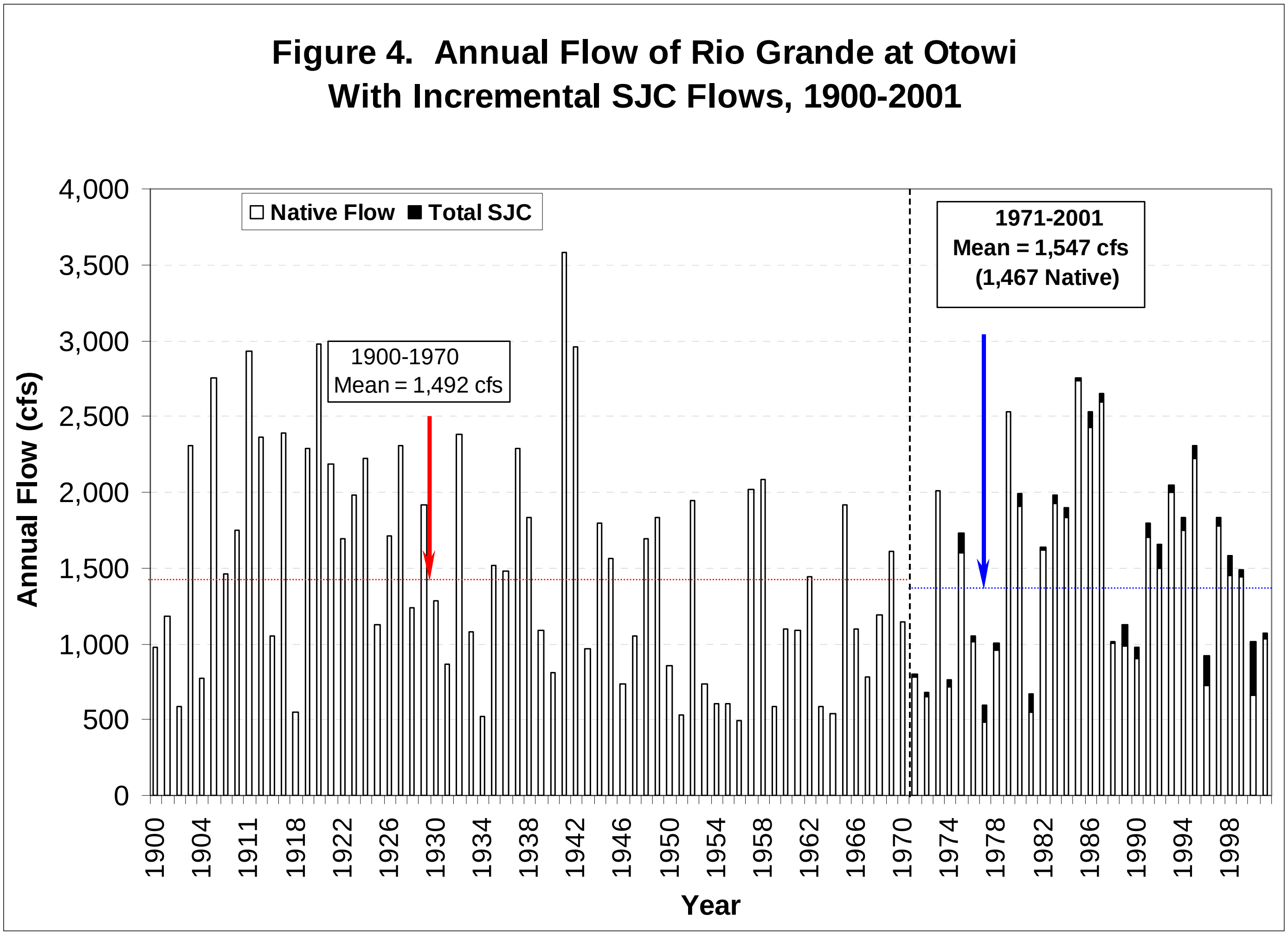
This evaluation involves several steps:

- Review of the historical streamflow and suspended sediment records for the Rio Grande at Otowi, approximately 4 miles upstream of the Buckman intake site.
- Selection of a range of streamflow and sediment conditions from which to simulate the diversion of water and return of sediment to the river.
- Using a sediment mass balance algorithm, estimation of suspended sediment concentrations in the river below the intake for various rates of diversion, streamflow, and ambient river suspended sediment concentrations.

Summary of Historical Streamflow and Sediment Records

Figure 1 shows the proposed project intake location on the Rio Grande at Buckman some 4 miles downstream of the State Highway 4 Bridge at Otowi. The U.S. Geological Survey (USGS) gage at Otowi has one of the longest and most complete records of streamflow in the United States, with daily flow data available from 1895 to present (uninterrupted since 1900). The USGS Otowi gage is also the key accounting gage for the Rio Grande Compact that regulates water operations and water rights among the states, including a separate accounting of SJC water released from Heron Reservoir for use by various contractors in the Rio Grande Basin (including the City, the County, and Las Campanas).

The long-term record of annual flows at Otowi shows that river discharge has averaged about 1,510 cfs (1.09 million ac-ft/yr) over the 1900-2001 period. SJC water began flowing through the Rio Grande at Otowi in 1971. Over the pre-SJC importation period 1900 to 1970, Otowi flows averaged 1,492 cfs (see Figure 4). Over the post-SJC period of 1971-2001, flows at Otowi averaged 1,547 cfs. The post-SJC period includes imported SJC water that has averaged 80 cfs since 1971. Subtraction of the 80 cfs from the 1971-2001 total average flow of 1,547 cfs results in an estimated average 'non-SJC' flow of 1,467 cfs for 1971-2001 – very close to the 1,492 cfs average 'non-SJC' flow for the 1900-70 period.



The seasonal runoff pattern of the river at Otowi is shown in Figure 5. The snowmelt runoff period generally begins in late March and early April and proceeds to a peak in May or June. After June, streamflow at Otowi usually declines through July and August to a base flow of less than 1,000 cfs for much of the September to February period. In the peak snowmelt runoff months May and June, flows are typically more than 3,000 cfs. As indicated in Figure 5, the attenuation of flood peaks in the May-July period (caused by storage in Abiquiu Reservoir which began in 1963) and releases of SJC water (typically heavy in the late irrigation season months of August-October), have altered the runoff hydrograph – particularly over the period since 1971.

Figure 5. Mean Monthly Flow at Otowi,1971-2001

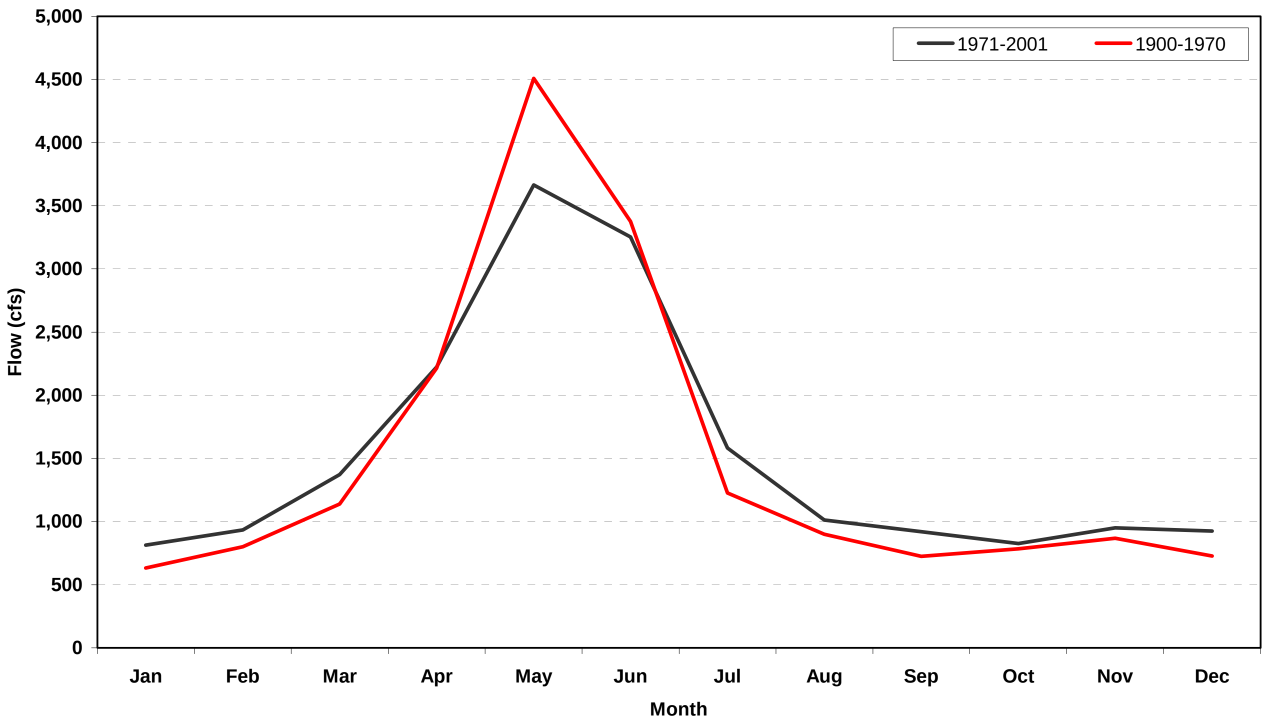


Table 2 provides a summary of tabulated monthly flows for the Rio Grande at Otowi for the 1971-98 period. Note that for the 1971-2001 period, the minimum monthly flows of 260 to 360 cfs occurred in September and October.

From the above graphical and tabular summaries, the seasonal flow pattern of the Rio Grande at Otowi from 1971-2001 can be characterized as follows:

- Fall-winter, low flow — September through February; September and October have flows augmented somewhat by irrigation releases and occasional thunderstorms. Mean flows typically 850 to 950 cfs, minimums typically 260 to 500 cfs.
- Pre-snowmelt, moderate flow — March and April; early snowmelt can begin in April in some years. Mean flows typically 1,400 to 2,300 cfs, minimums 500 to 600 cfs.
- Spring snowmelt, high flow — May and June; snowmelt can extend into July in wet, cooler years. Mean flows generally 3,300 to 3,800 cfs, minimums can be as low as 450 to 500 cfs in years of poor snowpack, but more typically are about 1,000 cfs.
- Summer monsoon, moderate flow — July through August; mean flows typically 1,000 to 1,500 cfs, but can be as low as 400 and as high as 3,000 cfs depending on strength (or lack of) monsoon.

Year	January Average (cfs)	February Average (cfs)	March Average (cfs)	April Average (cfs)	May Average (cfs)	June Average (cfs)	July Average (cfs)	August Average (cfs)	September Average (cfs)	October Average (cfs)	November Average (cfs)	December Average (cfs)	**Annual Average (cfs)**
1971	721	877	1,141	1,215	898	528	568	463	396	910	1,151	735	**800**
1972	688	862	1,274	741	433	470	394	391	449	689	1,020	734	**679**
1973	685	692	1,161	1,851	5,514	4,909	3,125	1,612	1,033	845	922	1,681	**2,003**
1974	1,326	717	1,161	936	1,032	1,031	668	769	263	361	429	450	**762**
1975	473	562	956	2,078	3,680	4,023	2,681	968	976	821	1,485	1,959	**1,722**
1976	1,046	695	897	1,342	2,611	1,430	1,168	1,009	979	470	434	510	**1,049**
1977	436	526	612	489	639	1,162	838	633	467	493	401	488	**599**
1978	445	500	671	877	2,830	2,419	1,110	811	536	441	686	672	**1,000**
1979	565	649	1,683	3,506	6,616	7,914	3,579	1,169	741	819	1,618	1,477	**2,528**
1980	677	866	1,018	2,570	6,351	5,943	1,954	786	545	490	1,296	1,391	**1,991**
1981	688	590	631	606	833	956	735	642	415	564	740	581	**665**
1982	558	659	1,064	2,087	4,105	4,125	1,425	1,189	1,547	1,026	1,009	878	**1,639**
1983	746	954	1,475	2,480	5,054	6,162	3,087	952	704	527	589	1,036	**1,980**
1984	717	730	1,462	3,060	6,786	4,601	1,038	895	722	732	1,026	1,025	**1,900**
1985	993	1,021	2,346	6,412	8,390	6,471	1,503	1,081	1,047	1,218	1,272	1,252	**2,751**
1986	1,757	2,510	2,328	3,782	4,441	5,776	3,230	704	876	1,373	2,034	1,606	**2,535**
1987	1,294	2,641	3,127	5,225	7,285	4,219	1,500	1,379	1,532	1,554	1,399	763	**2,660**
1988	701	772	1,470	1,910	1,725	1,103	749	854	808	522	811	752	**1,015**
1989	731	810	2,026	3,397	1,653	844	1,023	807	586	558	476	575	**1,124**
1990	550	619	878	1,062	1,693	1,056	1,093	919	1,065	769	1,103	851	**972**
1991	848	1,063	1,524	3,055	4,562	3,460	1,390	1,523	1,115	692	1,215	1,129	**1,798**
1992	862	1,033	1,784	3,968	3,734	2,899	1,240	1,076	1,161	860	624	708	**1,662**
1993	900	1,140	1,559	3,101	5,518	4,806	1,629	1,213	1,328	836	1,259	1,243	**2,044**
1994	878	869	1,603	3,476	5,881	4,026	1,037	818	866	853	737	945	**1,833**
1995	974	1,243	1,945	2,301	4,682	6,484	4,548	1,009	1,046	1,127	1,258	1,034	**2,304**
1996	1,176	1,300	1,305	872	1,169	1,122	806	847	758	603	538	611	**926**
1997	707	857	1,474	1,569	4,274	4,389	1,340	1,209	1,467	2,225	1,382	1,012	**1,825**
1998	949	967	1,349	1,702	3,570	1,840	1,336	1,203	1,284	966	780	746	**1,391**
1999	798	779	765	1,015	3,603	3,086	1,514	2,132	1,553	1,040	804	725	**1,485**
2000	772	798	987	1,123	1,333	1,603	1,470	1,347	1,164	552	465	525	**1,012**
2001	543	618	830	1,130	2,748	1,957	1,239	977	1,052	694	454	574	**1,068**

1971-2001 Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Minimum	436	500	612	489	433	470	394	391	263	361	401	450	**599**
95% Daily Min.	448	518	637	552	506	515	391	340	268	313	401	430	**NA**
Maximum	1,757	2,641	3,127	6,412	8,390	7,914	4,548	2,132	1,553	2,225	2,034	1,959	**2,751**
Mean	813	933	1,371	2,224	3,666	3,252	1,581	1,013	919	827	949	925	**1,539**
Median	731	810	1,305	1,910	3,680	3,086	1,336	968	976	769	922	763	**1,639**
Std. Dev.	286	483	565	1415	2206	2128	989	350	363	382	410	385	**641**

Table 2. Monthly Rio Grande Flows at Otowi, 1971-2001

Low-Flow Frequency and Basis of Intake Design

As a basis for the operational design of the proposed diversion at Buckman, a low-flow design value is necessary. From inspection of the Otowi flow record, it was determined that only a few scattered days of flows less than 200 cfs had occurred since the mid-1960s at the Otowi gage. Thus, we reasoned that a flow of about 200 cfs was a good first approximation of a design low-flow value for the Buckman intake.

Surveys of the channel bottom and hydraulic analysis (Heggen, 2001) indicated that flows in the channel at the Buckman intake site should be sufficiently deep to permit operation at a peak diversion rate of 32 cfs at a river flow of 200 cfs. With that conclusion in hand, it was left to estimate the likely frequency of a flow of 200 cfs at Otowi (assumed as identical to flows that would occur at Buckman).

We applied standard USGS frequency analysis techniques (*Low-Flow Investigations by H. C. Riggs, Chapter B1, Techniques of Water-Resources Investigation of the U.S. Geological Survey, 1972*) to the hydrologic record at the Otowi gage. The analysis was based on the daily flow record for 1971-2001 (the post-SJC project period) and a Gumbel-type power function fit to the gaged data.

Results are illustrated in Figure 6 in terms of recurrence frequency (in years) of consecutive mean daily low flows of 1, 7, 14, 30, and 60 days. The 7-day values are considered to be representative of those most likely to come into play in operating the diversion (i.e., operational decisions are likely to be made on a forecasted weekly or biweekly runoff outlook rather than on a day-to-day basis). Figure 6 suggests that a consecutive 7-day low flow averaging 200 cfs might occur about once every 60 years[1].

Another important issue is when within a given year a 7-day low flow is likely to occur. If such a flow occurred in June or July when municipal water demands are normally highest, diversion of up to 32 cfs (intake capacity) would have a larger effect on river flows in the 200-cfs range. However, as indicated in Figure 7, more than 50 percent of the 7-day low flows are most likely to occur in September and October — whereas virtually none are likely in June and only 7 percent of low flows are forecast to occur in July.

[1] In reality, post-2005 years are likely to see more SJC water in the river at Otowi than occurred previously, with a tendency to make less frequent the low flows predicted in the above analysis (Figure 6). Under its proposed Drinking Water Project, Albuquerque will for the first time in SJC Project history be taking full delivery of its SJC supply from Abiquiu at an average of about 66 cfs. Similarly, the Santa Fe users will be taking a larger delivery of SJC water for this project—up to nearly 7,000 ac-ft/yr (10 cfs on average and perhaps 28 cfs during peak periods). In contrast, records provided by Sangre de Cristo Water Company (Amy Lewis, written communication, 2002) suggests that releases of Santa Fe SJC for water rights offset purposes for Buckman pumping averaged about 2,000 ac-ft/yr in the last decade.

Figure 6. Frequency Curves of Annual Lowest Mean Discharge for Consecutive Days at Otowi Gage on Rio Grande

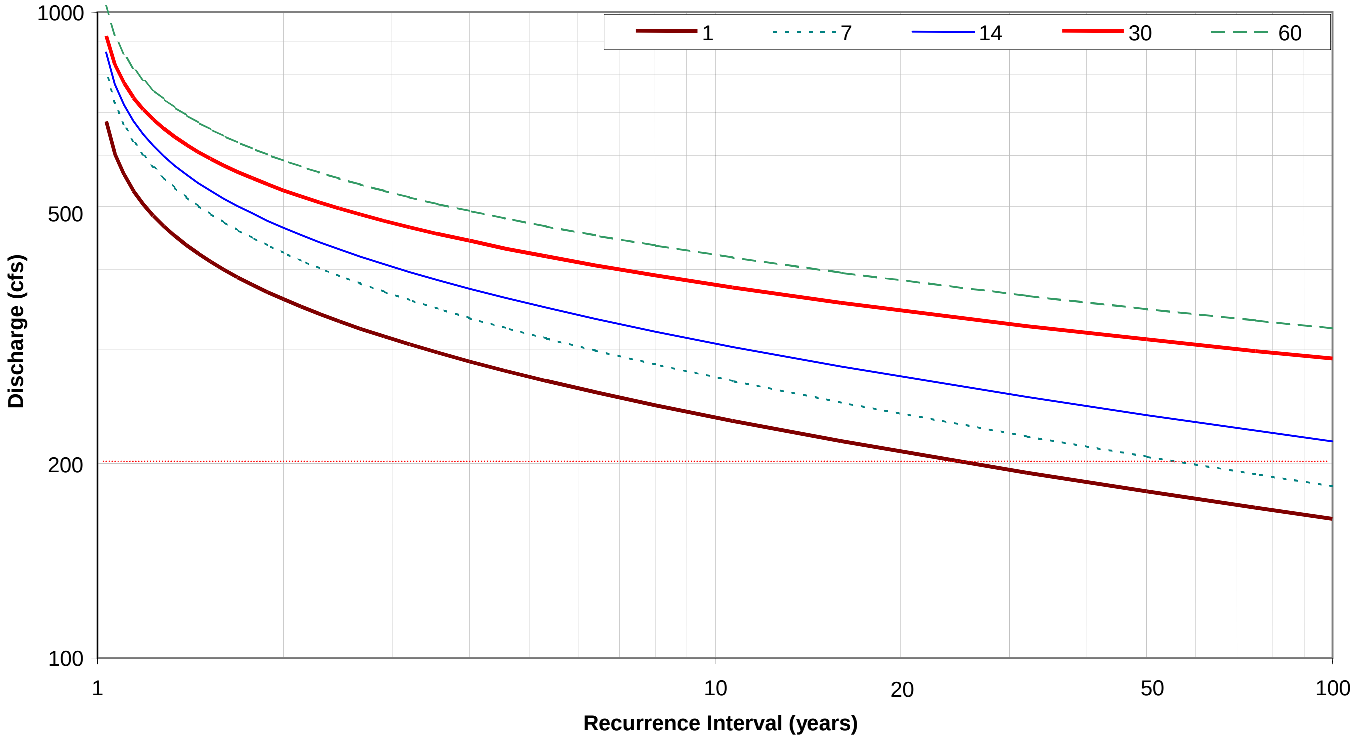


Figure 7. Reccurence of 7-Day Low Flow by Month, 1971-98

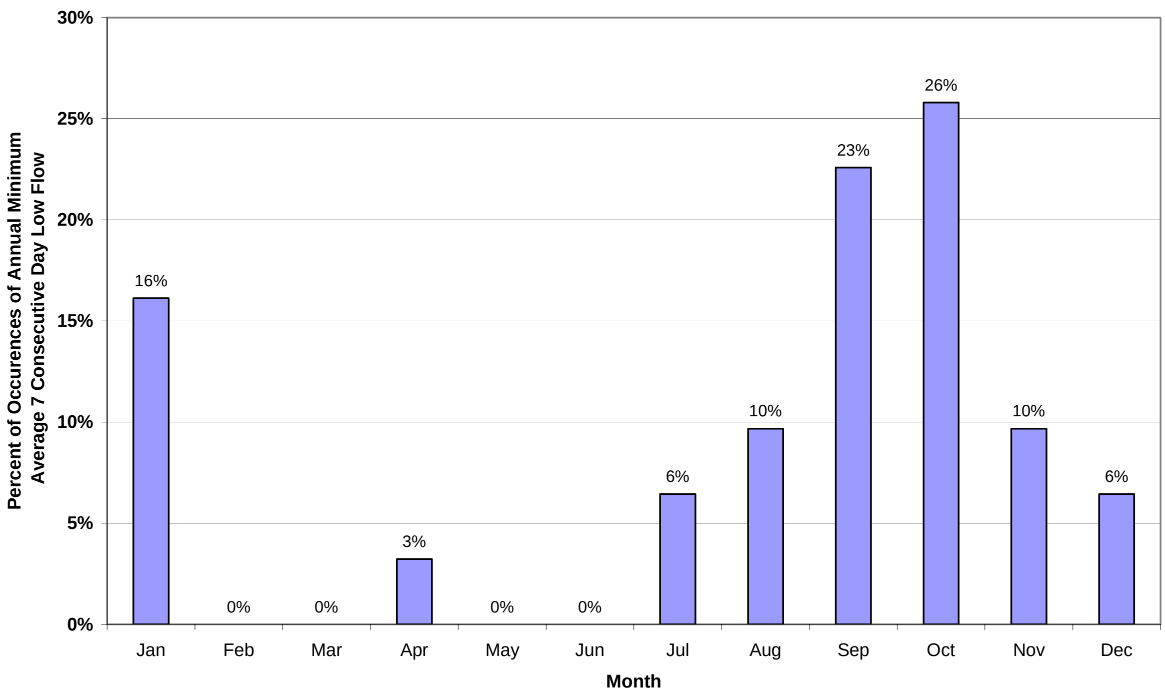


Table 3 summarizes various values and indices of observed 1971-2001 Rio Grande flows and their relation to proposed maximum Buckman diversions on a monthly basis. Note that the proposed maximum diversions are a very small percentage (generally <2 percent) of median monthly river flow. In comparison to the 95th percentile minimum daily river flow, the maximum proposed Buckman diversions comprise about 2 to 8 percent (the latter in September) of 95th percentile minimum daily river flow.

In summary, a 7-day low flow of 200 cfs and an estimated recurrence frequency of 50 to 60 years would seem to be reasonable values (and probably conservative) for purposes of low-flow operational design for a project river intake at Buckman. The 95th percentile daily minimum flow, based on analysis of historic records for the Otowi gage, is estimated at 268 cfs (with a likely occurrence in September). From Tables 1, 2, and 3, it is highly unlikely that a peak demand (i.e., peak diversion from a Buckman intake) of 28.2 cfs (June peak day) would occur coincident with a 50 to 60-year minimum monthly flow of 200 cfs or a 95th percentile daily flow of 268 cfs. Minimum monthly June flows at Buckman are likely to be over 300 cfs whereas 95th percentile daily low flows should be more than 500 cfs. It would appear that the likely period of maximum impact on the Rio Grande would occur in September when extreme minimum 7-day lows could approach 200 cfs and peak-day diversions could be as high as 22 to 23 cfs.

Table 3. Relationship of Proposed Buckman Diversions to Rio Grande Flow

Month	Max. Monthly Net Diversion (cfs)	1971-2001 Otowi Flow		Diversion as % of:	
		95th Percentile Daily Minimum Flow (cfs)	Median Monthly (cfs)	95th Percentile Daily Minimum Flow	Median Monthly Flow
January	11.3	448	731	2.5	1.5
February	12.7	518	810	2.4	1.6
March	14.1	637	1,305	2.2	1.1
April	18.2	552	1,415	3.3	1.3
May	23.8	506	3,680	4.7	0.6
June	28.2	515	3,086	5.5	0.9
July	26.1	391	1,336	6.6	2.0
August	23.8	340	968	7.0	2.5
September	22.6	268	976	8.4	2.3
October	19.6	313	769	6.3	2.5
November	14.1	401	922	3.5	1.5
December	11.3	430	763	2.6	1.5

Suspended Sediment Evaluation

Suspended sediment data have been collected on a daily basis at the USGS Otowi gage since 1955 and since 1946 on a periodic basis. From these data, a series of graphs relating flow to suspended sediment concentration were produced from the post-1955 record. Our evaluation, as well as an earlier study by Heggen (2001) indicated that while there was a general relationship wherein daily suspended sediment concentration increased with increasing flow, the relationship was highly variable and often not predictable. Attempts to develop relationships on a seasonal basis (i.e., monsoons only, snowmelt period only) were also not successful.

Consequently, we collated the daily flow and suspended sediment into monthly averages in an attempt to develop a better general relationship. This resulted in the data depicted in Figure 8 — observed average monthly flow versus observed average monthly suspended sediment concentrations at the Otowi for the period 1955 to 1995. An 'upper-bound' curve was drawn, which appears to be reasonable for purposes of conservatively estimating suspended sediment concentrations as a function of flow. The curve in Figure 8 was used to estimate suspended sediment concentrations for river flows ranging from 200 to 5,000 cfs.

As described previously, the project is intended to remove and return the >0.25-mm sand fraction of the suspended sediment to the river. Thus, an estimate of the relative percentage of the >0.25-mm size fraction was needed. Figure 9 shows the available USGS data for size analysis from samples taken from the Otowi sampling site. Figure 9 indicates that the >0.25-mm sand fraction varies widely, but that, on average, was about 12 percent of the total suspended sediment concentration. Evaluation of individual concentrations versus river flow indicated no strong relationship between flow and percent sand — again suggesting that the percentage of >0.25-mm material, on average, remained about the same despite changes in flow and total suspended sediment concentration.

Figure 10 depicts the general relationship between observed turbidity concentrations and suspended sediment concentrations based on the available data from the Otowi sampling site.

Figure 8. Flow Versus Suspended Solids Concentration, Rio Grande at Otowi

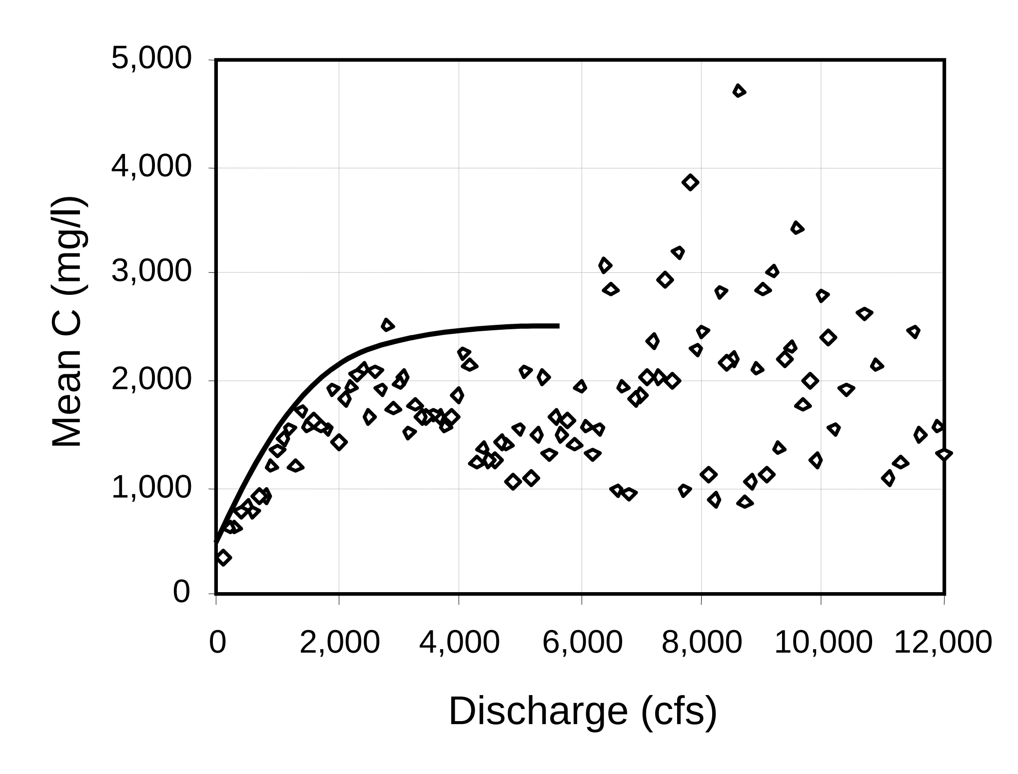


Figure 9. Size Analysis of Suspended Sediment, Rio Grande at Otowi

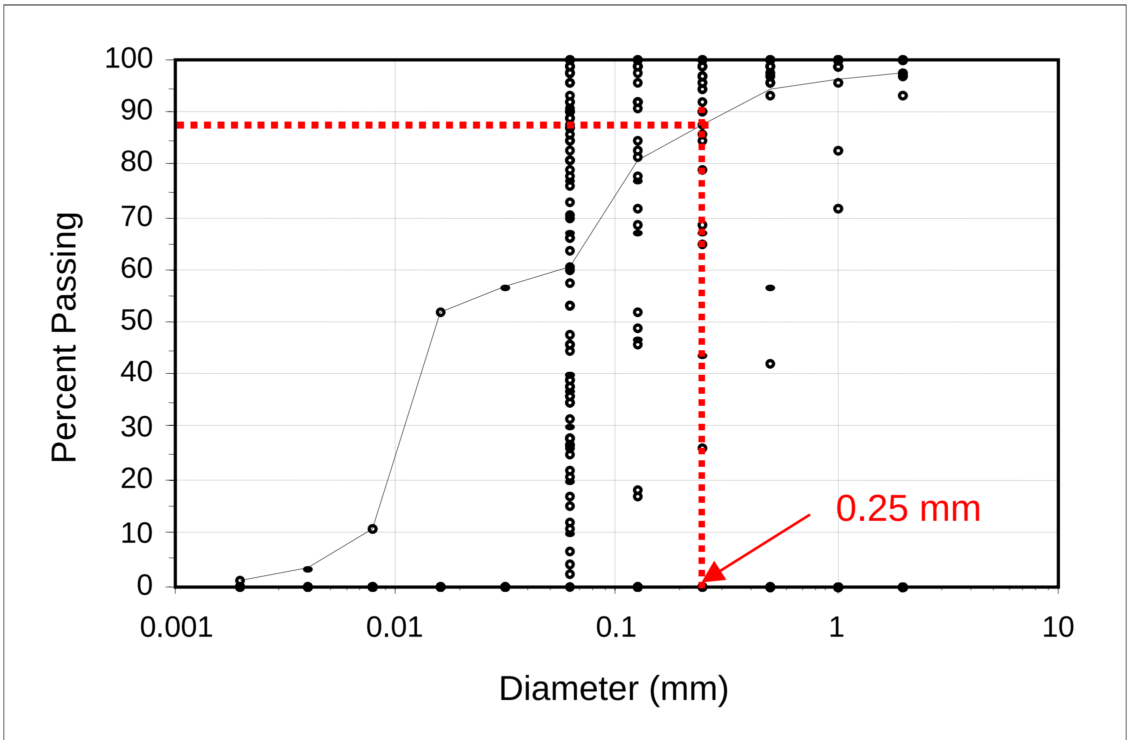
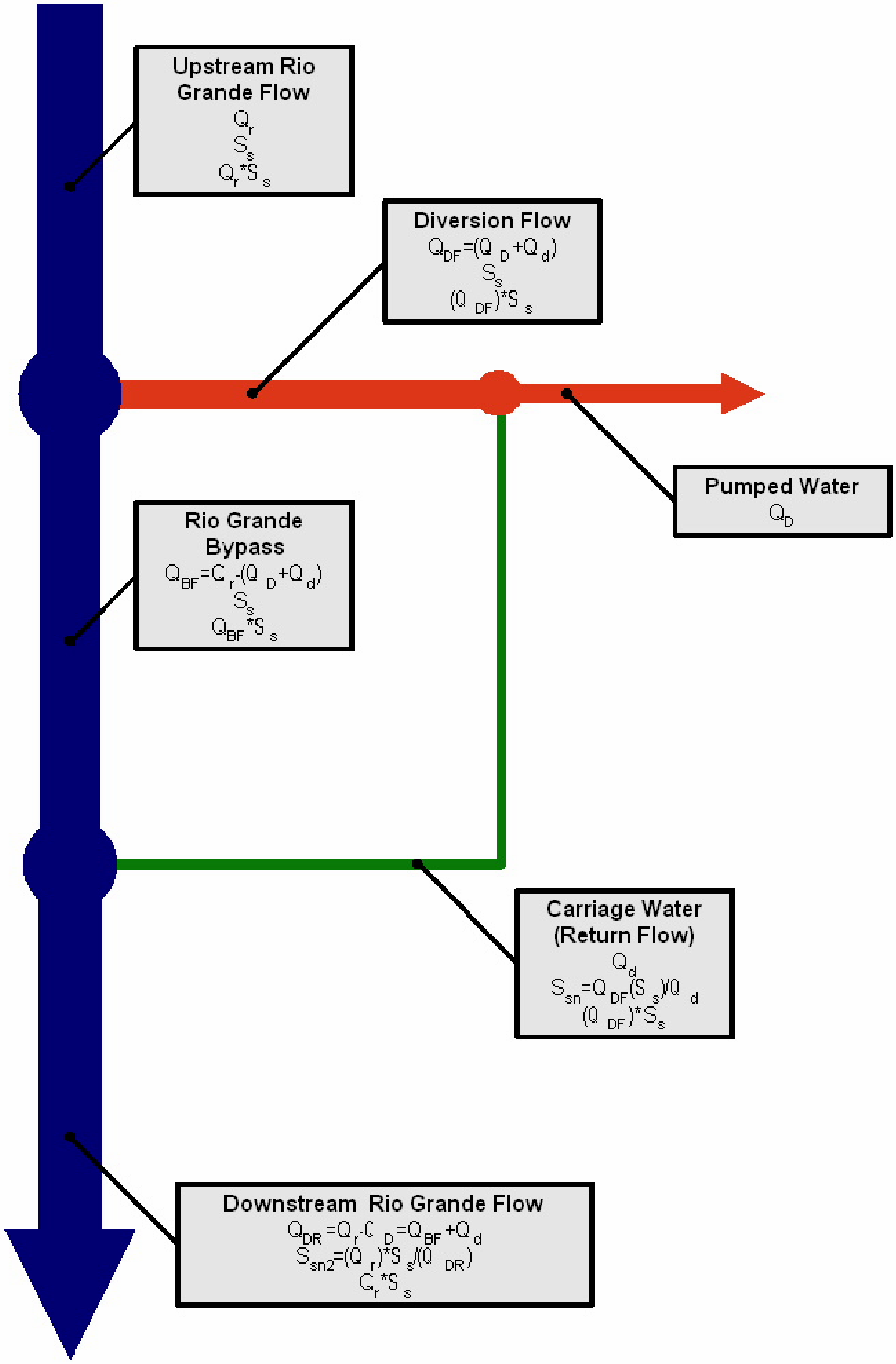


Figure 10. Suspended Sediment Mass Balance Flowchart



Mass Balance Calculations

Based on the relationships presented above, a mass balance calculation spreadsheet was prepared to simulate the concentrations of suspended sediment in the river below the Buckman diversion, as well as in the diverted water and in the return flow (including the added sand >0.25 mm) to the river below the diversion. The results are presented in the graphs in Appendix A and in the Mass Balance Calculations spreadsheet included in Appendix B. The net effects on the Rio Grande were calculated as difference in total suspended solids (TSS) concentration and percent change in TSS concentration upstream and downstream of the diverted and returned flows.

As discussed previously, the Rio Grande normally has distinctive seasonal flow regimes, as well as large annual fluctuations in flow during drought and wet years. Data were reviewed to determine the appropriate variables that should be used in the calculations. From review of the historical data on flow and suspended sediment, calculations were completed for upstream river flows of 200, 500, 1,000, 2,000, 3,000, 4,000, and 5,000 cfs using the corresponding suspended sediment concentration taken from the relationship depicted in Figure 8. Each upstream river flow was incorporated into the calculations using assumed Buckman diversion rates of 28, 21, 14, and 7 cfs. These diversion rates more than cover the estimated peak-day demands for the Buckman project presented in Tables 1 and 3. Each diversion rate was further subdivided in the calculations using carriage water return flow rates of 2 and 4 cfs. It is anticipated that during periods of higher diversion (e.g., 28 cfs), as much as 4 cfs of diverted carriage water will be used to return the >0.25-mm sand to the river, whereas during periods of lower diversion (e.g., 7 cfs), as little as 2 cfs of carriage water will be used.

Sand concentrations of 8, 12, and 16 percent were then entered into the calculations for each combination of upstream flow rate, diversion rate, and return flow rate. The sand concentration range was selected to bracket the expected range depicted by historical data. Figure 9 shows that approximately 12 percent, on average (but with a wide range), of the sediment particles are retained on the 0.25-mm-diameter screen.

Table 4 presents the variables used in the mass balance calculations presented in the Mass Balance Calculations spreadsheet in Appendix B.

The Mass Balance Calculations spreadsheet includes the following as depicted in Figure 10:

- Suspended sand (i.e. >0.25-mm-diameter) concentration in river (upstream)
- Suspended fines (i.e. <0.25-mm-diameter) concentration in river (upstream)
- Sand load in river (upstream)
- Diversion sand load (total diversion = pumped water + carriage water)
- Pumped water sand load
- Diverted carriage water sand load
- Diverted carriage water fines load
- Bypass river flow (post-diversion river flow, but before the return flow inlet)
- Bypass river flow TSS load
- Return flow TSS load

Table 4. Variables Used to Calculate the Mass Balance of TSS

Description		Variable or Equation
River Upstream		
Flow (Discharge = Q)		Q_R
Total Suspended Sediment Concentration		S_{ST}
Suspended Sand Concentration		S_S
Suspended Fines Concentration		S_F
Suspended Sand Load		$Q_R \times S_S$
Diversion (Pumped + Diverted Carriage Water)		
Diversion Flow (Pumped flow, does not include carriage water)		Q_D
Diverted Carriage (Return) Water Flow		Q_d
Suspended Sand Concentration (same as upstream)		S_S
Suspended Fines Concentration (same as upstream)		S_F
Suspended Sand Load		$(Q_D + Q_d) \times S_S$
Suspended Fines Load		$(Q_D + Q_d) \times S_F$
Not Diverted River Flow (Bypass)		
Not Diverted Flow		$Q_{BF} = Q_R-(Q_D+Q_d)$
Suspended Sand Concentration (same as upstream)		S_S
Suspended Fines Concentration (same and upstream)		S_F
Suspended Sand Load		$(Q_R - (Q_D + Q_d)) \times S_S$
Suspended Sand Load		$(Q_R - (Q_D + Q_d)) \times S_F$
Return Flow (Carriage Water)		
Borrowed Return Flow		Q_d
Includes All of the Suspended Sand of the Total Diversion – Concentration of Suspended Sand		$((Q_D + Q_d)/Q_d) \times S_S$
Suspended Sediment Load		$(S_S Q_D) + (S_S Q_d) + (Q_d S_F)$
Return Flow TSS Concentration		$(S_S Q_D) + (S_S Q_d) + (Q_D S_F)/Q_d$
River Downstream		
Downstream Flow		$Q_R - (Q_D + Q_d) + Q_d = Q_R - Q_D$
Suspended Fines Concentration		$S_s\ (Q_R/(Q_R - Q_D))$
Downstream TSS Load		$S_{DST} = (S_S Q_D) + (S_S Q_d) + (Q_D S_F) + (Q_{BF} S_{ST})$
Downstream TSS Concentration		$S_{DST}/(Q_d + Q_{BF})$

- Total downstream TSS load
- Return flow TSS concentration
- Downstream TSS concentration
- Percent increase in TSS concentration downstream

Note that for purposes of calculating the downstream TSS concentration (after return flow from the diversion-sedimentation system) we have that the river is completely mixed. Our observations of hydraulic conditions in the vicinity of the diversion facility and immediately downstream where the sand return would occur, suggests that the river should be in a completely mixed condition approximately 1,000 feet downstream at the rapids caused by boulders washed into the channel from the Canada Ancha arroyo system. We anticipate that the return to the river will be done by jetting the return flow of 2 to 4 cfs into the fast-moving portion of the river on the downstream side of the diversion structure. We envision that the final design of the diversion facility and return flow system will include actual field tests and hydraulic dispersion-advection calculations to ensure an efficient mixing with the river.

Example Mass Balance Calculations

The following examples in Table 5 demonstrate the calculation algorithm used in the mass balance analysis.

- Example 1 assumes the following conditions: 200 cfs upstream flow, 28 cfs diversion rate, 12 percent sand concentration (i.e. percent of suspended sediment particles >0.25 mm in diameter), 4 cfs carriage water, and 750 milligrams per liter (mg/L) upstream TSS concentration.
- Example 2 assumes the same variables with the exception of 1,000 cfs upstream flow and 1,600 mg/L upstream TSS concentration.
- Example 3 assumes the same variables as Examples 1 and 2 with the exception of 2,000 cfs upstream flow and 2,100 mg/L upstream TSS concentration.

Downstream TSS Concentrations

As shown above from the example calculations, removing the sand from the pumped diversion water, returning it to the carriage water flow, and discharging the sand to the river downstream of the diversion results in a TSS increase of only 4 to 15 mg/L — an essentially unmeasureable 0.17 to 1.95 percent increase.

To explore more fully the percentage increase in downstream TSS concentrations resulting from operation of the Buckman diversion, a series of graphs were developed from mass balance calculations to depict diversion rate versus percent increase in TSS as a function of river flow and upstream TSS concentrations. The following graphs show the post-return flow downstream TSS increase as a function of the diversion rate at each of three sand concentrations (i.e., suspended sediment particles >0.25 mm in diameter), 8, 12, and 16 percent, and upstream river flows of 200, 1000, and 2000 cfs.

Figure 11 shows the scenario for a 200-cfs upstream flow in the Rio Grande. As indicated by the figure, a sand concentration of 8 percent results in the lowest downstream TSS concentration increase and the sand concentration of 16 percent results in the highest downstream TSS concentration increase. At a sand concentration of 16 percent, the post-return flow downstream TSS concentration increase in the Rio Grande is about 2.60 percent.

Table 5. Example Mass Balance Calculations

Description	Calculation and Units	Example 1 Result	Example 2 Result	Example 3 Result
Upstream Flow	Q_R (cfs)	200	1,000	2,000
Diversion Rate	Q_D (cfs)	28	28	28
Diverted Carriage Water (Returned)	Q_d (cfs)	4	4	4
Percent Sand-Sized Particles (>0.25 mm)	%	12	12	12
TSS Concentration in River	S_{ST} (mg/L)	750	1,600	2,100
Suspended Sand Concentration in River	S_S (mg/L)	90	192	252
Suspended Fines Concentration in River	S_F (mg/L)	660	1,408	1,848
Sand Load in River	Q_R x S_S (mg/s)	5.09E+05	5.43E+06	1.42E+07
Diversion Sand Load – Total Diversion	(Q_D+Q_d) x S_S (mg/s)	8.2E+04	1.7E+05	2.3E+05
Pumped Water Sand Load	$Q_{D\ x}$ S_S (mg/s)	71,358	152,231	199,804
Pumped Water Fines Concentration – in pipe to high-head pumps	Same as in River S_F (mg/L)	660	1,408	1,848
Diverted Carriage Water Sand Load	Q_d x S_S (mg/s)	10,194	21,747	28,543
Diverted Carriage Water Fines Load	Q_d x S_F (mg/s)	74,756	159,480	209,318
Bypass River Flow (Not Diverted)	$Q_{BF} = Q_R - (Q_D + Q_d)$ (cfs)	168	968	1,968
Bypass River Flow TSS Load	Q_{BF} x S_{ST} (mg/s)	3.57E+06	4.39E+07	1.17E+08
Return Flow TSS Load	$(S_SQ_D) + (S_SQ_d) + (Q_dS_F)$ (mg/s)	1.56E+05	3.33E+05	4.38E+05
Total Downstream TSS Load	$S_{DST} = (S_SQ_D) + (S_SQ_d) + (Q_DS_F) + (Q_{BF}S_{ST})$ (mg/s)	3.72E+06	4.42E+07	1.17E+08
Return Flow TSS Concentration	$(S_SQ_D) + (S_SQ_d) + (Q_DS_F)/Q_d$ (mg/L)	1,380	2,944	3,864
Downstream TSS Concentration	$S_{DST}/(Q_d + Q_{BF})$ (mg/L)	765	1,606	2,104
Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ (%)	2.00	0.375	0.19

Figure 11. Diversion Rate vs. TSS at 200 cfs Upstream Flow Rate

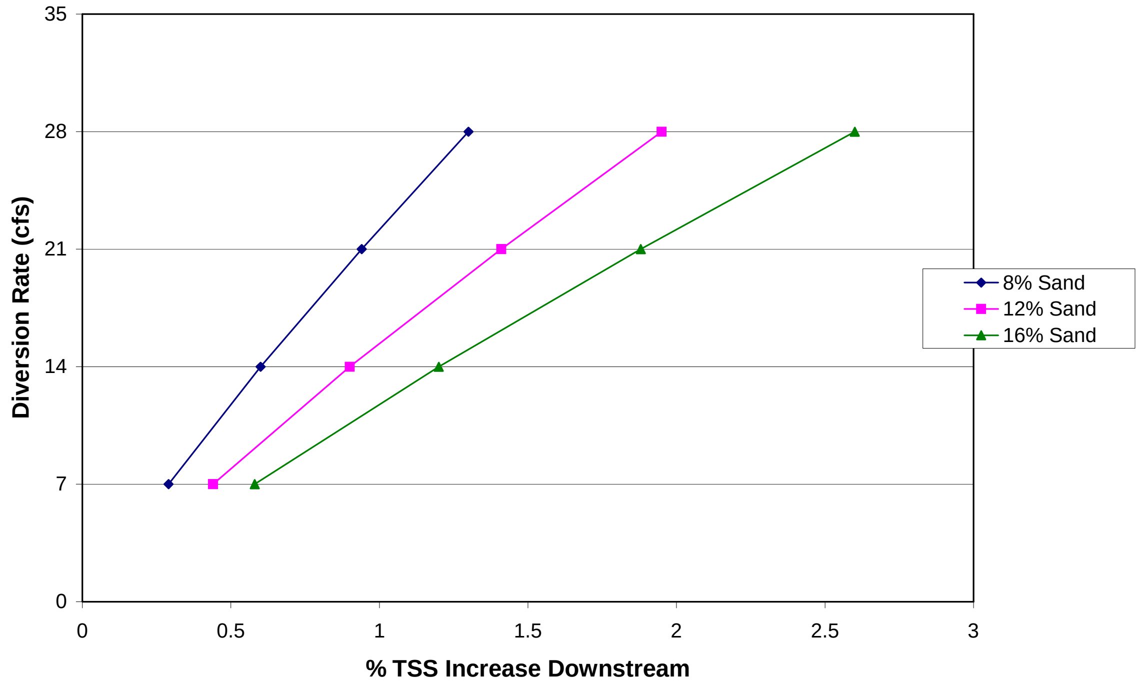


Figure 12 shows the 1,000-cfs upstream flow scenario, which is representative of a typical mid-summer condition not effected by thunderstorms. A sand concentration of 8 percent results in the lowest downstream TSS concentration increase and the sand concentration of 16 percent results in the highest downstream TSS concentration increase. At a sand concentration of 16 percent, the post-return flow downstream TSS concentration increase in the Rio Grande is only about 0.46 percent.

Figure 12. Diversion Rate vs. TSS at 1,000 cfs Upstream Flow Rate

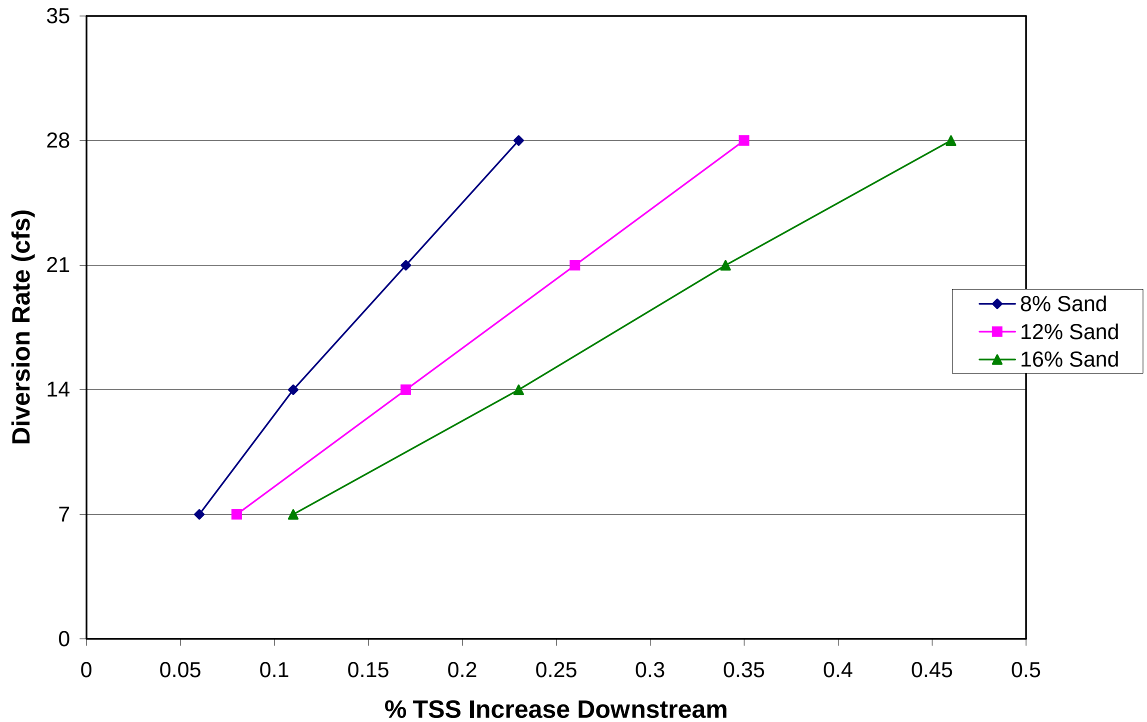
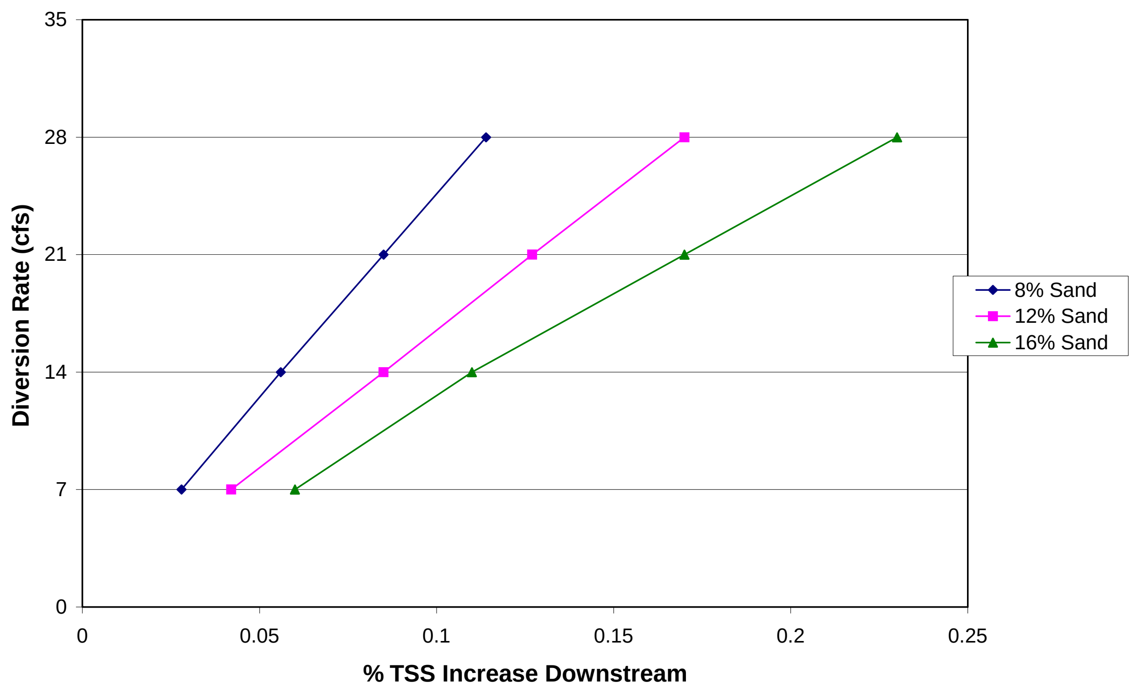


Figure 13 shows the 2,000-cfs upstream flow scenario, which is representative of an early summer condition during the period of snowmelt runoff. A sand concentration of 8 percent results in the lowest downstream TSS concentration increase and the sand concentration of 16 percent results in the highest downstream TSS concentration increase. At a sand concentration of 16 percent, the post-return flow downstream TSS concentration increase in the Rio Grande is 0.23 percent.

Figure 13. Diversion Rate vs. TSS at 2,000 cfs Upstream Flow Rate



Appendix A contains the complete set of graphs for each of the seven Rio Grande flow rates used in the mass balance calculations. As determined from the calculations and presented on the graphs, the TSS increases are dependent primarily on the upstream flow (Q_R), since this is the variable with the widest fluctuations over time. The highest TSS concentration increases were calculated to coincide with the lowest flow conditions, since the volume of diverted water represented a larger fraction of the flow in the Rio Grande. For example, with a 200-cfs upstream flow in the Rio Grande containing 750-mg/L TSS, a 32-cfs diversion of which 4 cfs is returned carriage water, and 16 percent sand concentration, the downstream TSS increase is 2.6 percent. This is the highest increase that was obtained from the calculations. In contrast, with a 5,000-cfs upstream flow in the Rio Grande containing 2,550-mg/L TSS, a 32-cfs diversion of which 4 cfs is returned carriage water, and 16 percent sand concentration, the downstream TSS increase is 0.09 percent. At a given diversion rate (e.g., 28 cfs) and correspondingly higher flows of the Rio Grande, the diversion becomes a smaller and smaller fraction of the total flow and the effect of the diversion on the overall downstream TSS concentrations of the Rio Grande becomes smaller.

Table 6 presents a partial summary of the calculated suspended sediment mass balances; the complete summary is presented in Appendix B.

The results of the mass balance calculations indicate that the TSS concentrations are increased very slightly downstream of the diversion project. The increases have been calculated to be in the range from about 0.01 to 2.6 percent. The calculations have shown that the higher the flow (and TSS concentrations) in the Rio Grande, the lesser the downstream increase in TSS from the diversion project.

Turbidity

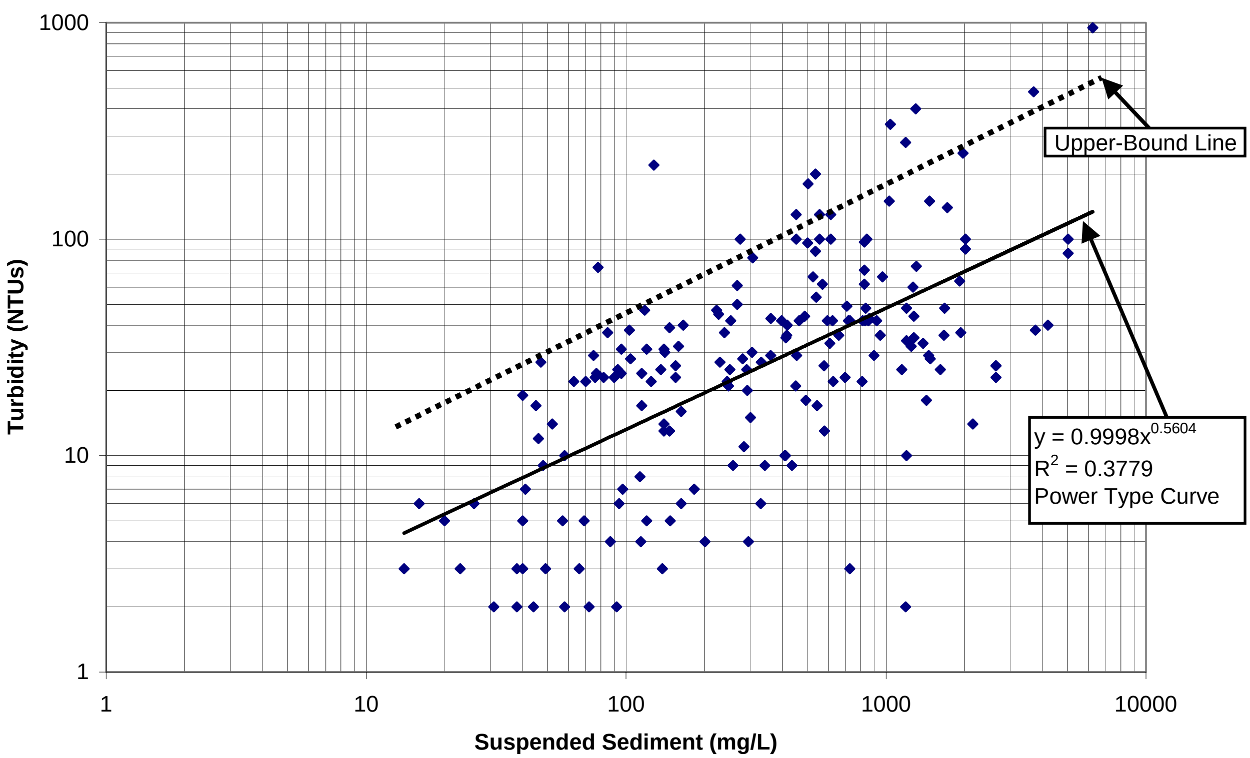
To evaluate the effect of slightly increased TSS concentrations in the river below the Buckman diversion on turbidity, we evaluated the observed historical relationship at Otowi between TSS and turbidity. The available turbidity data [nephelometric turbidity units (NTUs)] were plotted versus TSS (mg/L) data. A power curve was fit to the data, which on the log-log plot is shown as a straight line in Figure 14. An upper-bound line was also placed on the graph to show the approximate maximum turbidity that is associated with the suspended sediment concentration in the Rio Grande.

Figure 14 shows a general increase in turbidity with a corresponding increase in suspended sediment concentration. However, turbidity is generally more related to the type of event that is generating the flow. For example, a high intensity, but short duration thunderstorm is expected to result in higher turbidity than a snowmelt event. This is due to the mobilization of more, and presumably finer-grained, materials, resulting in higher turbidity during a thunderstorm event. Other factors, such as the relative amounts of loose sediments in tributary stream channels and the Rio Grande channel, the effects of previous flow events that may have removed turbidity-inducing fine-grained sediments and other geologic controls, will each have an effect on the turbidity in the Rio Grande at a given time.

Table 6. Summary of Suspended Sediment Mass Balances at 4-cfs Carriage Water and 12 Percent Sand Concentration

River (Q_R)	Diversion (Q_D)	TSS Upstream (mg/L)	Return Flow TSS (mg/L)	TSS Downstream (mg/L)	% TSS Increase in River Downstream
200	28	750	1,380	765	1.95
	21	750	1,223	761	1.41
	14	750	1,065	757	0.90
	7	750	908	753	0.44
1,000	28	1,600	2,944	1,606	0.35
	21	1,600	2,608	1,604	0.26
	14	1,600	2,272	1,603	0.17
	7	1,600	1,936	1,601	0.08
2,000	28	2,100	3,864	2,104	0.17
	21	2,100	3,423	2,103	0.13
	14	2,100	2,982	2,102	0.08
	7	2,100	2,541	2,101	0.04

Figure 14. Suspended Sediment Concentration versus Turbidity, Rio Grande at Otowi



References

CDM, September 2002. *Feasibility Study and Recommendations for San Juan-Chama Water Diversion*. Prepared for City and County of Santa Fe.

CDM, October 2001. Interim Progress Report: Development of Infrastructure Options for a Surface Diversion from the Buckman Area. Prepared for the City of Santa Fe.

CH2M HILL, October 2001. *Las Campanas Water Supply Project Feasibility Study*. Prepared for Las Campanas Santa Fe.

Heggen, R., 2001. *Preliminary Las Campanas Intake Sediment Study*. Prepared for CH2MHILL at the direction of Las Campanas Santa Fe. September 20.

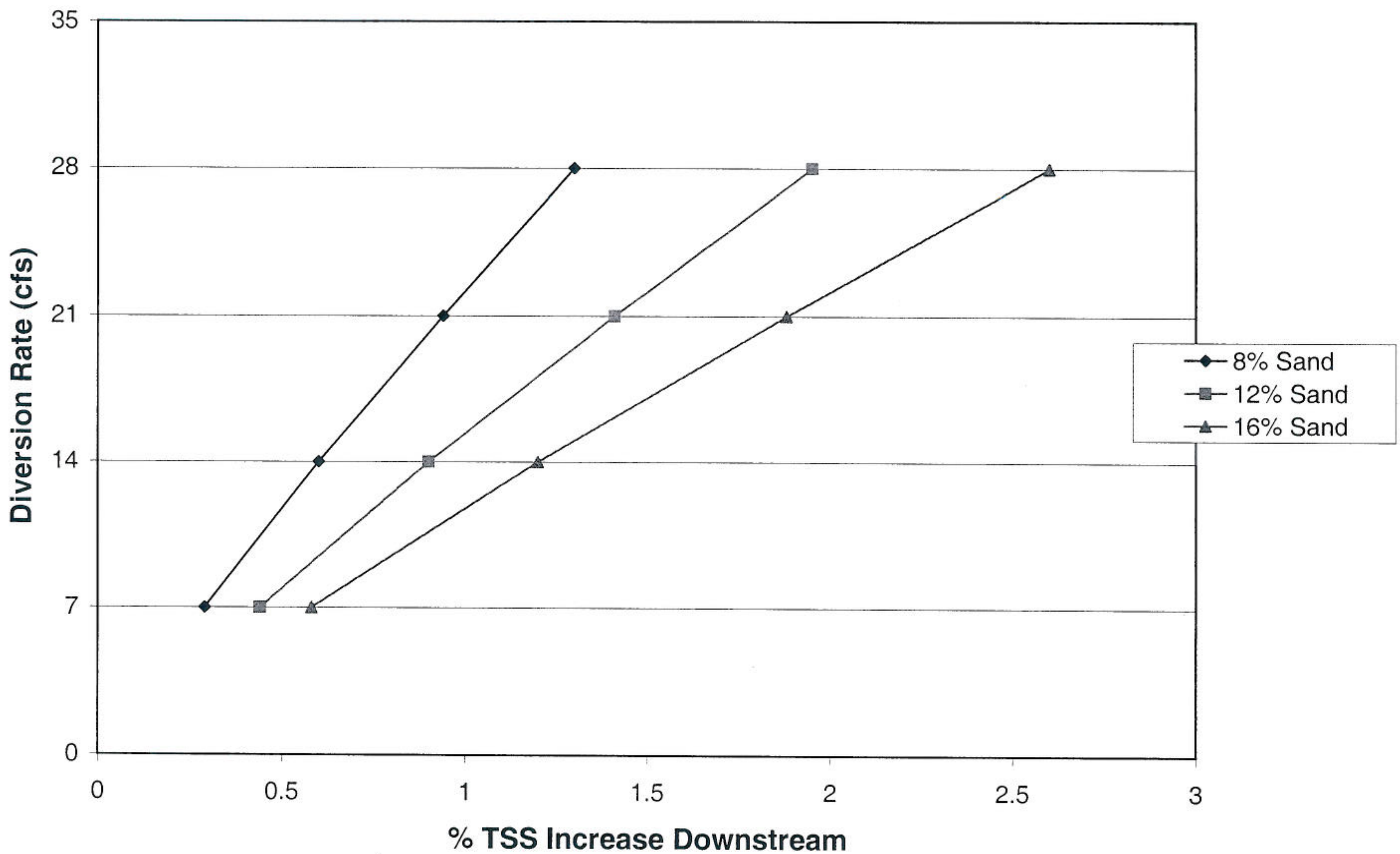
Rigg, H. C., 1972. *Low Flow Investigations.* Techniques of Water-Resources Investigation of the U.S. Geological Survey, Chapter B1.

Sangre de Cristo Water Company, 2002. Amy Lewis, written communication.

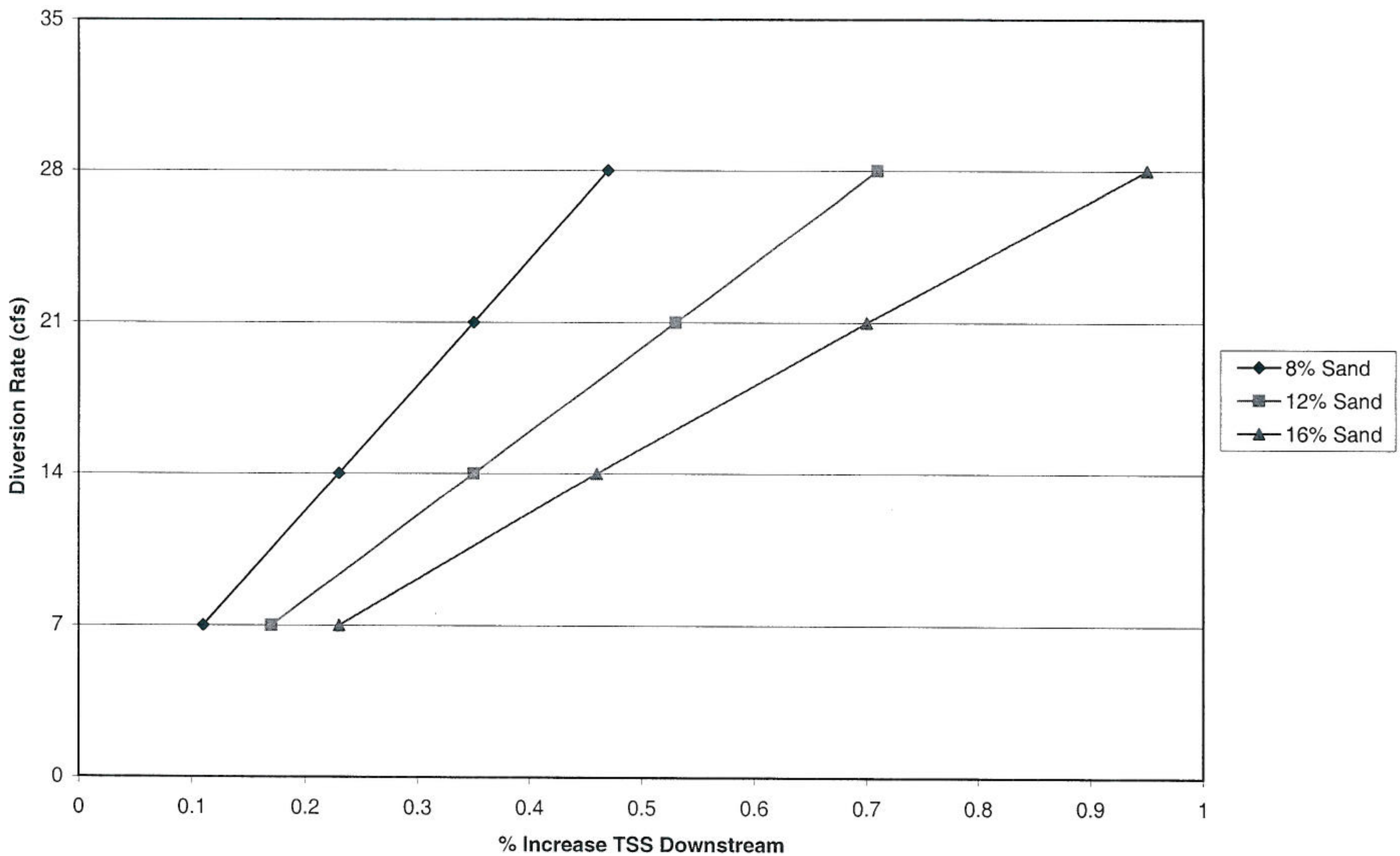
Appendix A.
Supporting Charts and Graphs

Diversion Rate Vs. Downstream TSS Increase Graphs

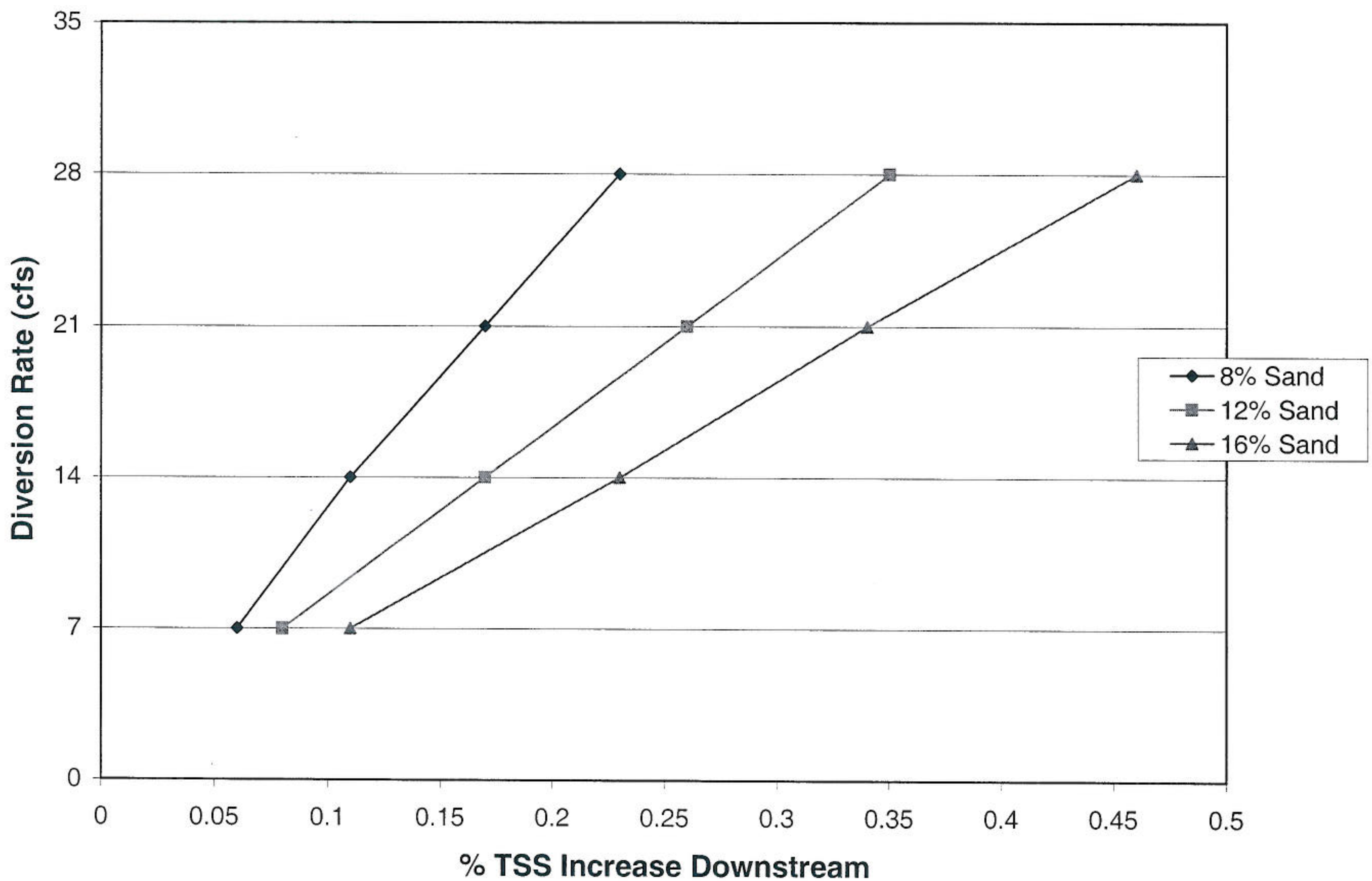
A.1. Diversion Rate (cfs) vs. Downstream TSS (%) Increase at 200 cfs Upstream Flow



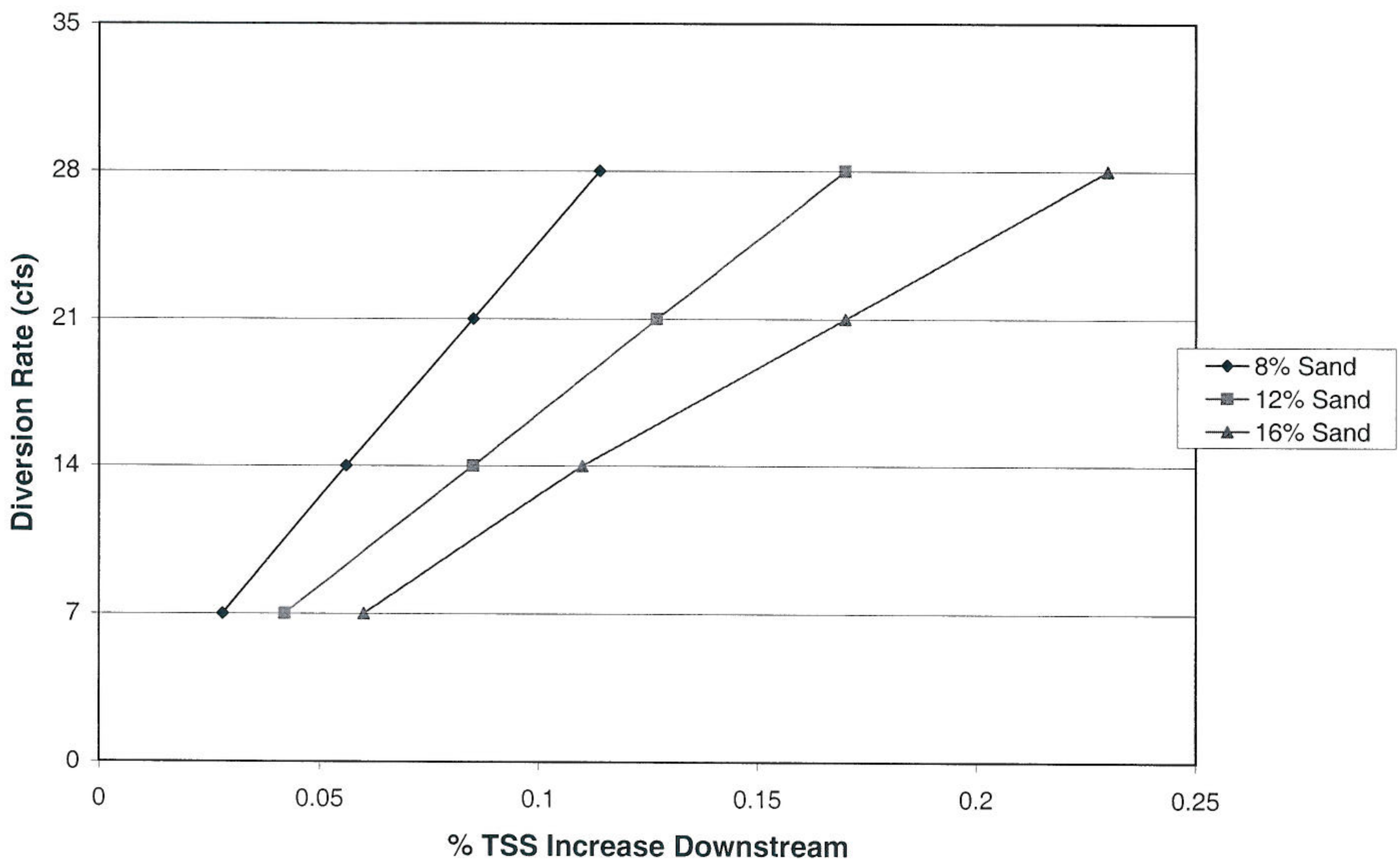
A.2. Diversion Rate (cfs) vs. Downstream TSS Increase (%) vs. 500 cfs Upstream Flow



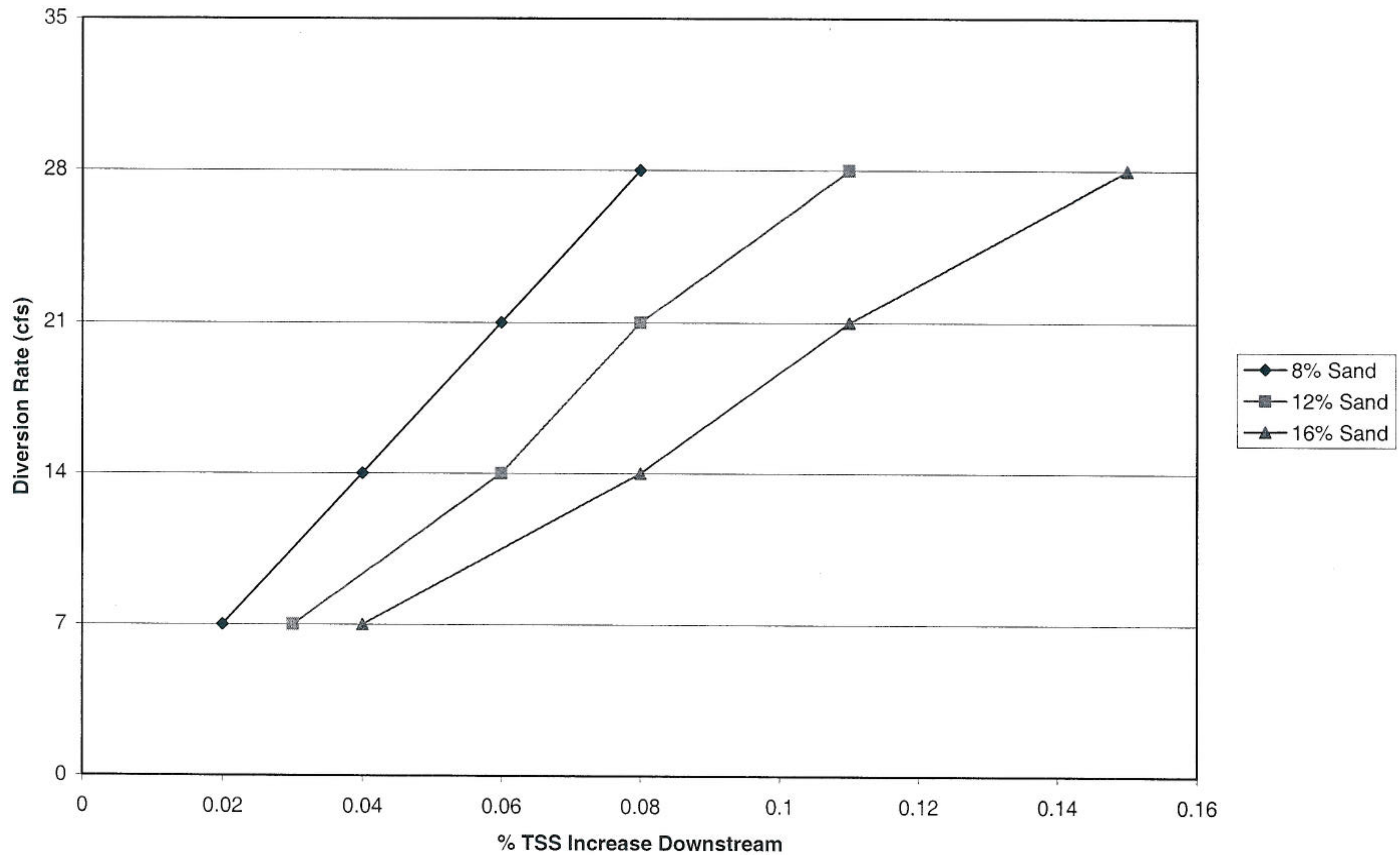
A.3. Diversion Rate vs. Downstream TSS Increase (%) at 1,000 cfs Upstream Flow



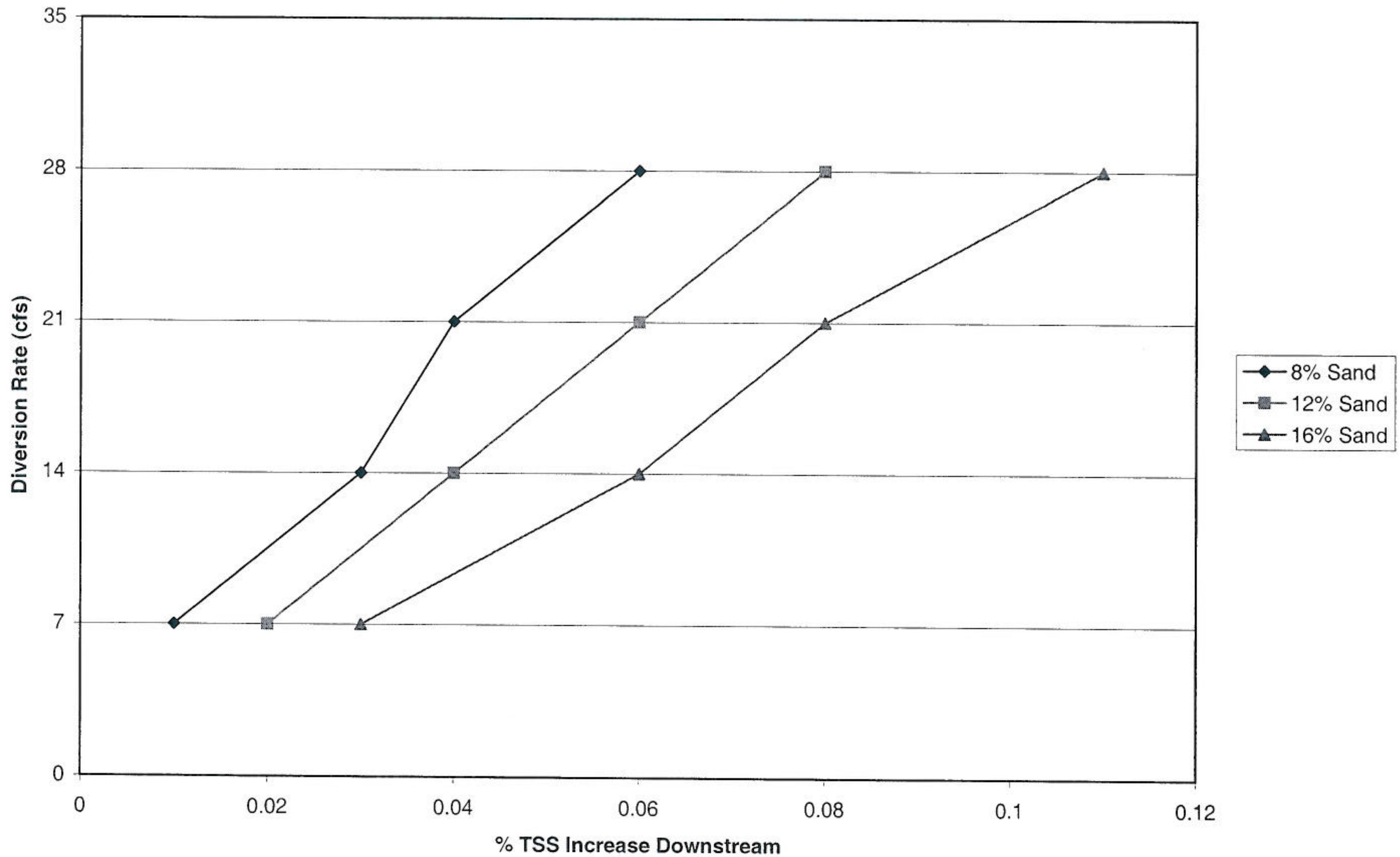
A.4. Diversion Rate (cfs) vs. Downstream TSS Increase (%) at 2,000 cfs Upstream Flow



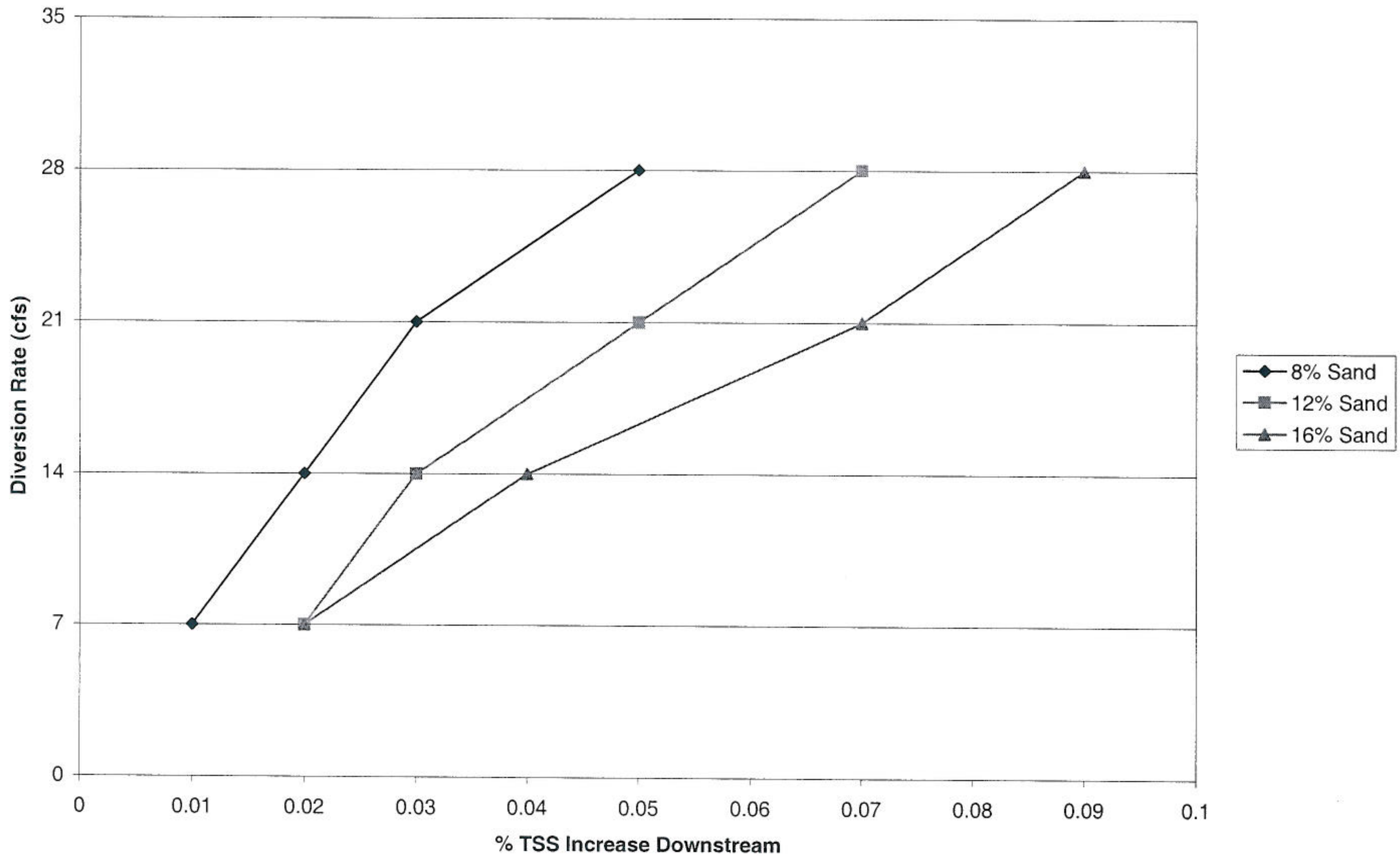
A.5. Diversion Rate (cfs) vs. Downstream TSS Increase (%) at 3,000 cfs Upstream Flow



A.6. Diversion Rate (cfs) vs. Downstream TSS Increase (%) at 4,000 cfs Upstream Flow

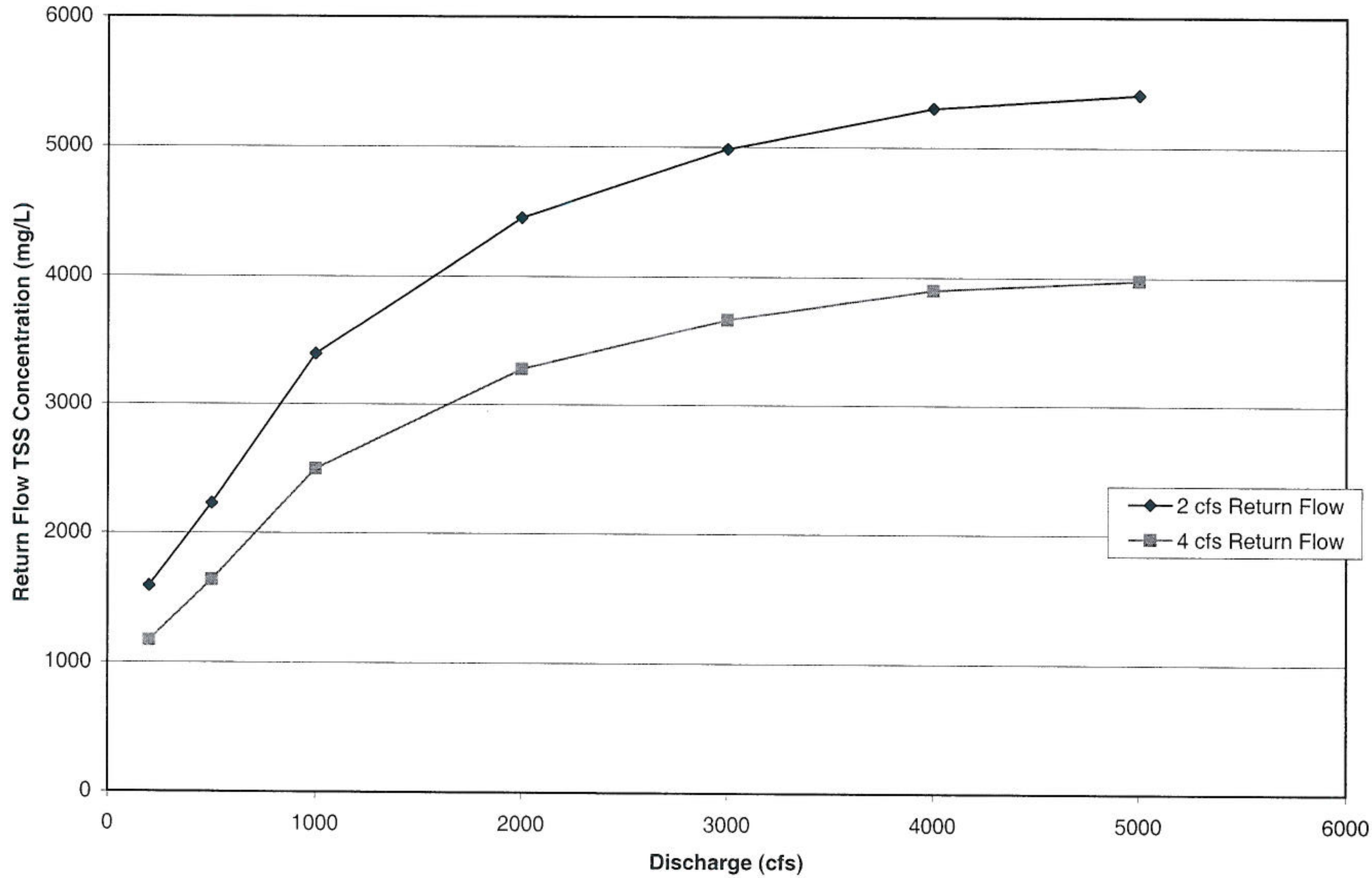


A.7. Diversion Rate (cfs) vs. Downstream TSS Increase (%) at 5,000 cfs Upstream Flow

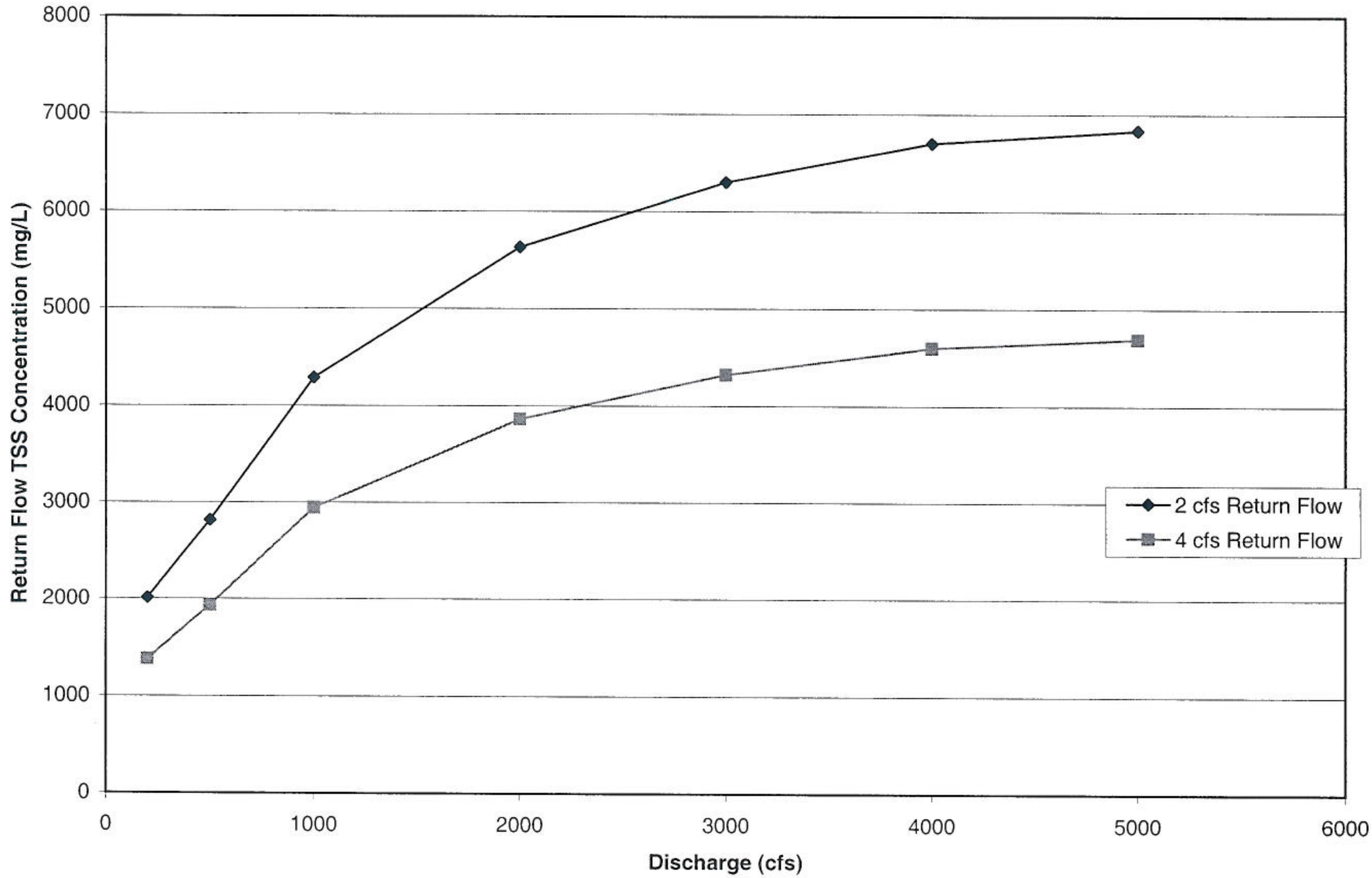


Return Flow TSS Vs. Upstream Flow Graphs

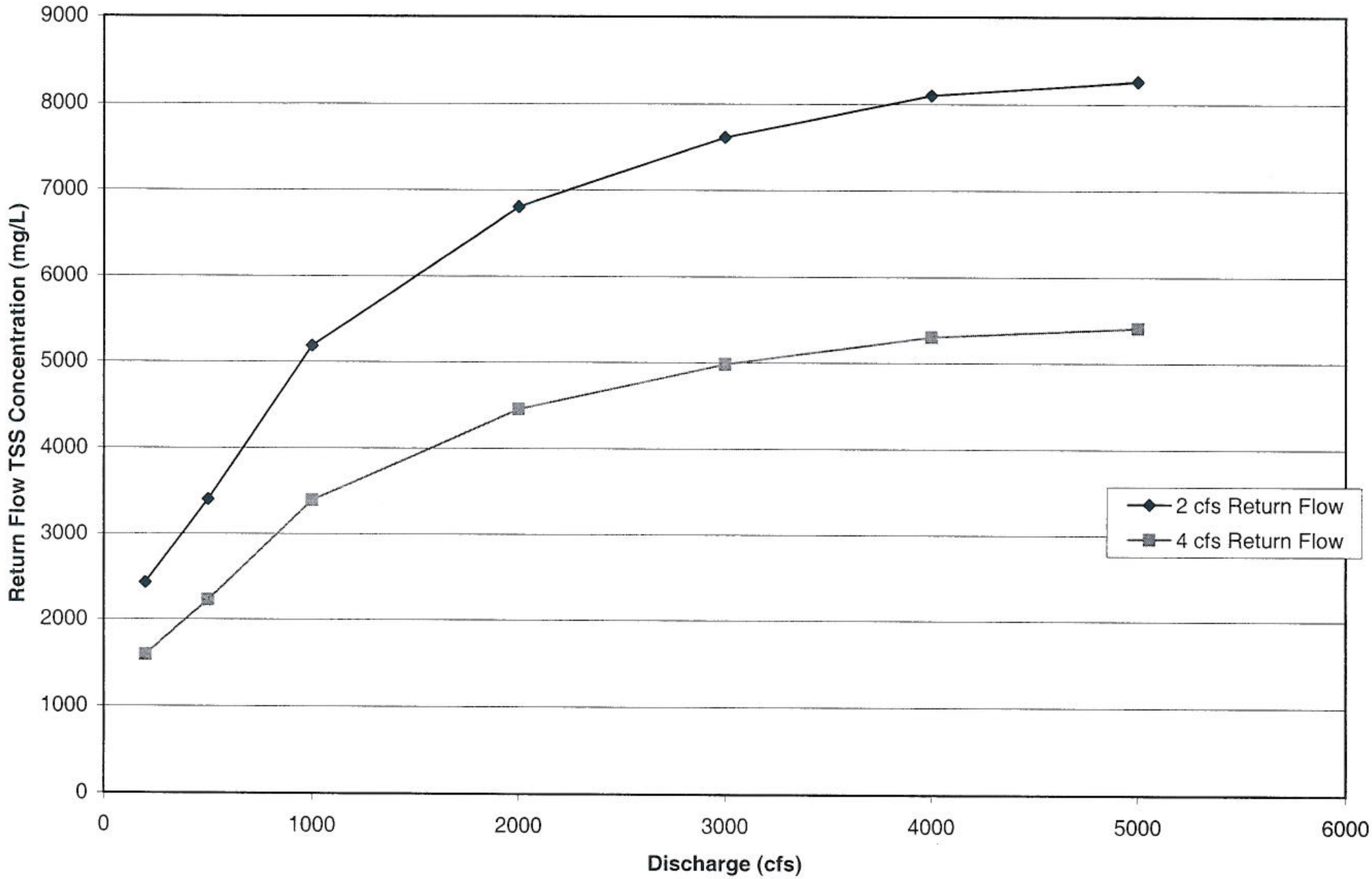
A.8. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
28 cfs Diversion Rate and 8% Sand Concentration



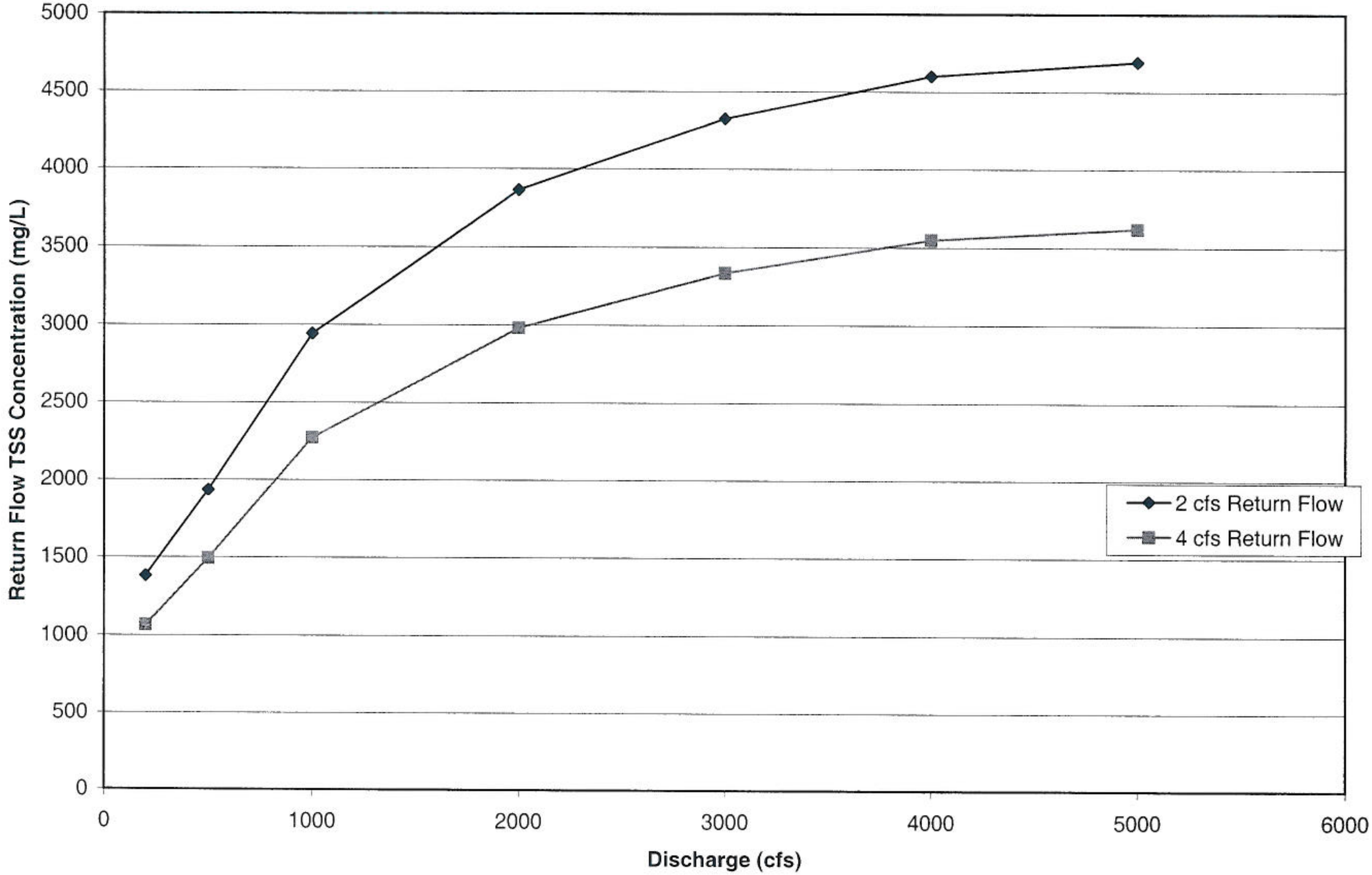
A.9. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
28 cfs Diversion Rate and 12% Sand Concentration



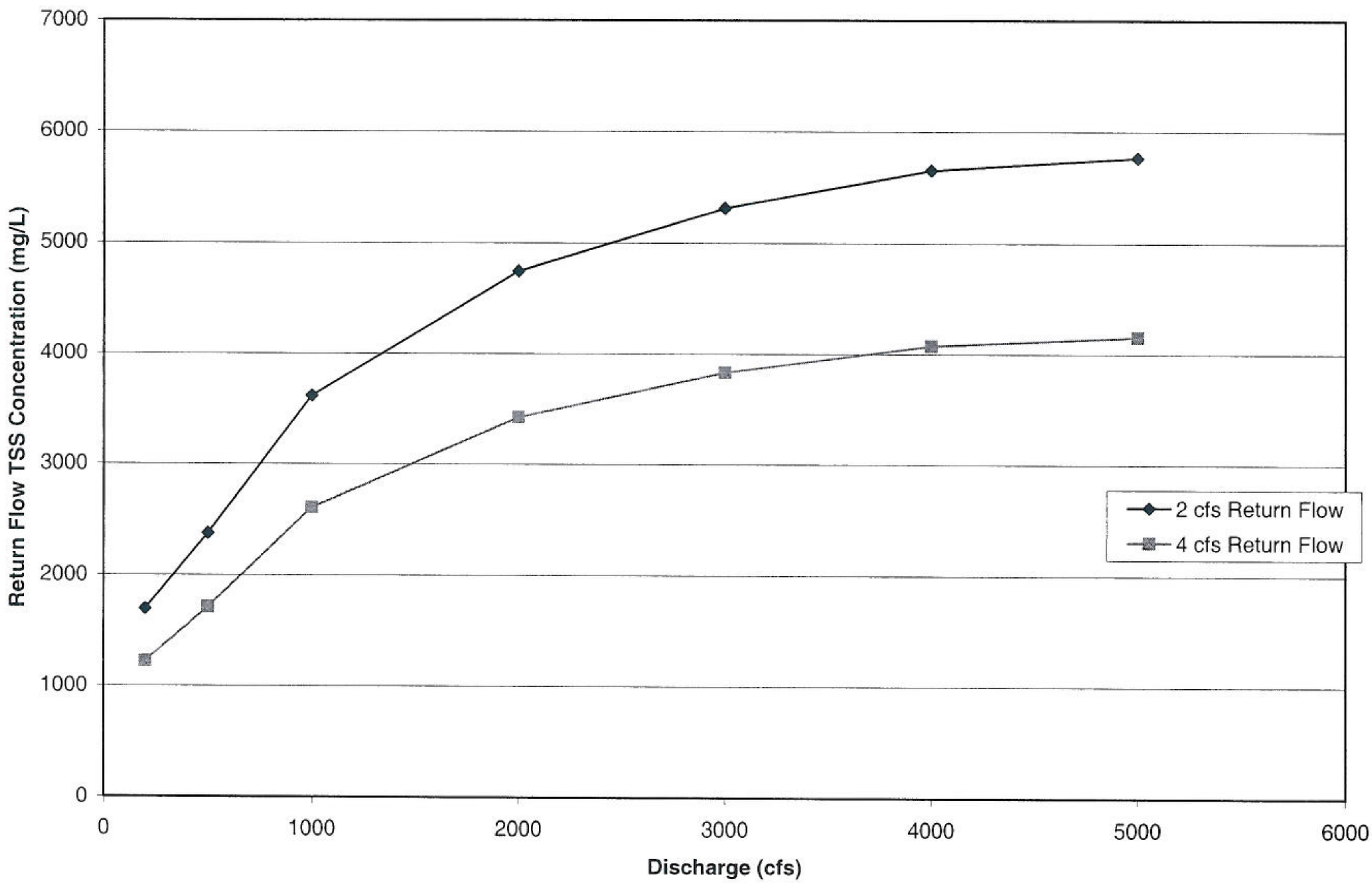
A.10. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
28 cfs Diversion Rate and 16% Sand Concentration



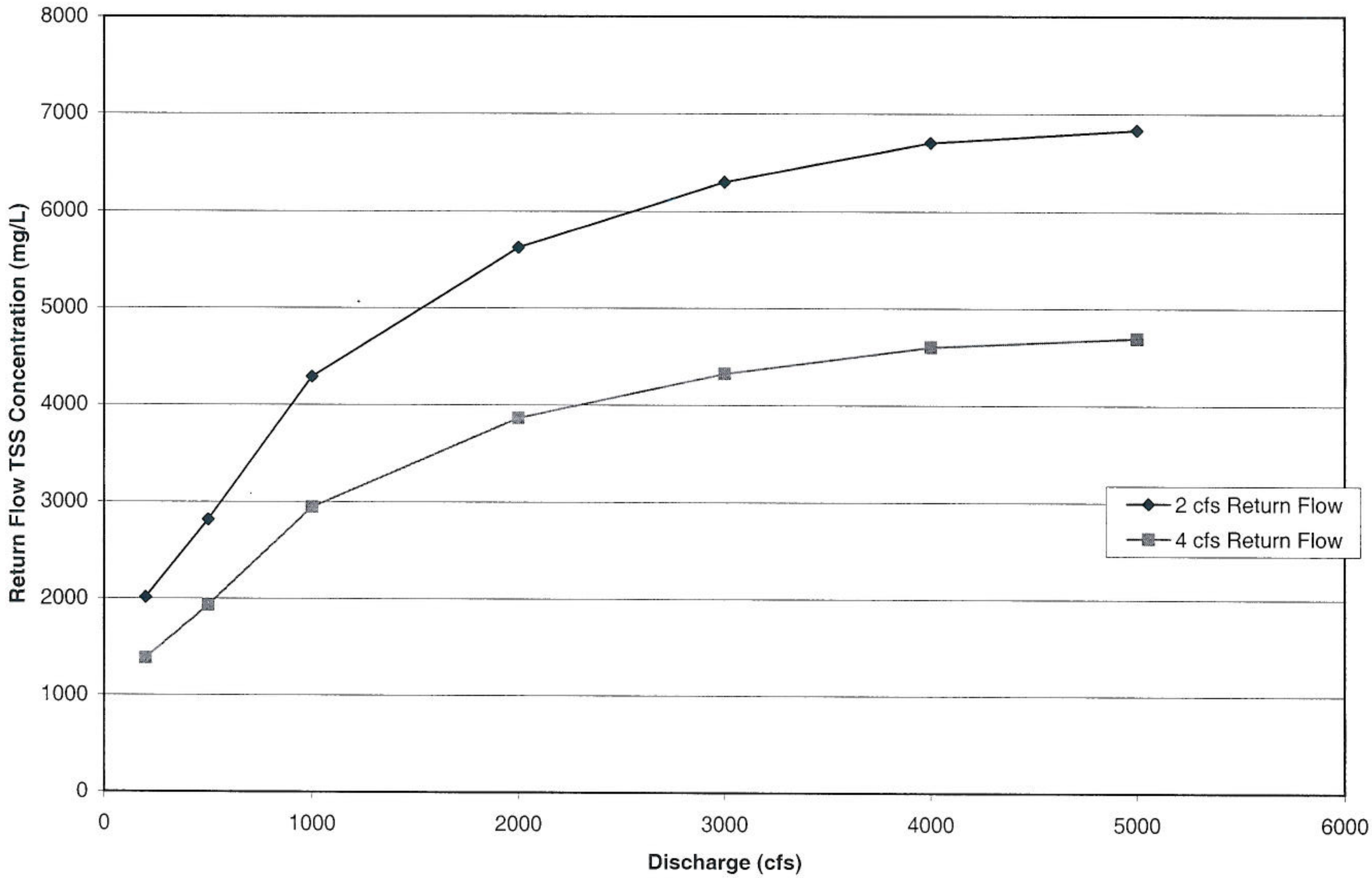
A.11. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
21 cfs Diversion Rate and 8% Sand Concentration



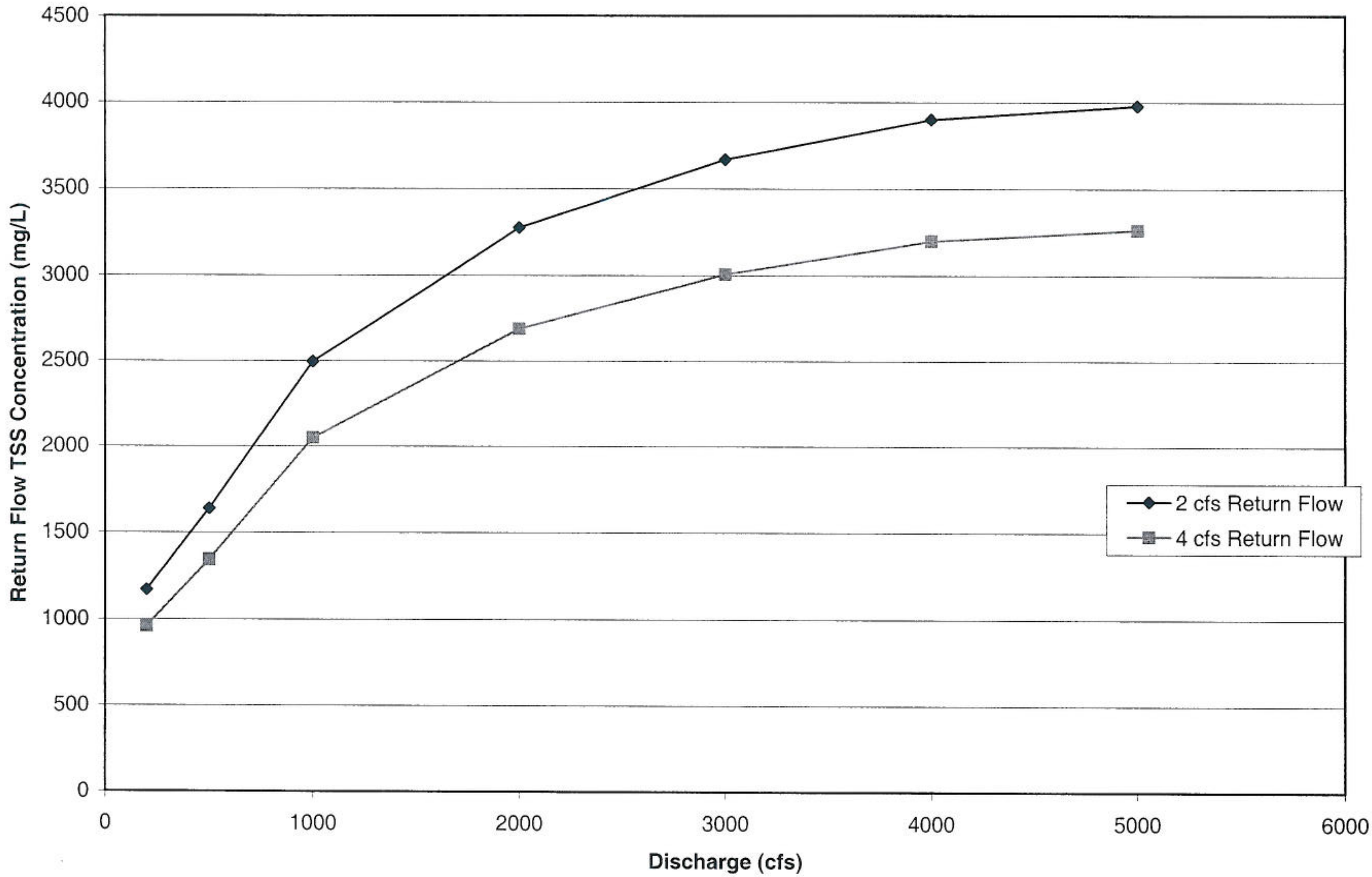
A.12. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
21 cfs Diversion Rate and 12% Sand Concentration



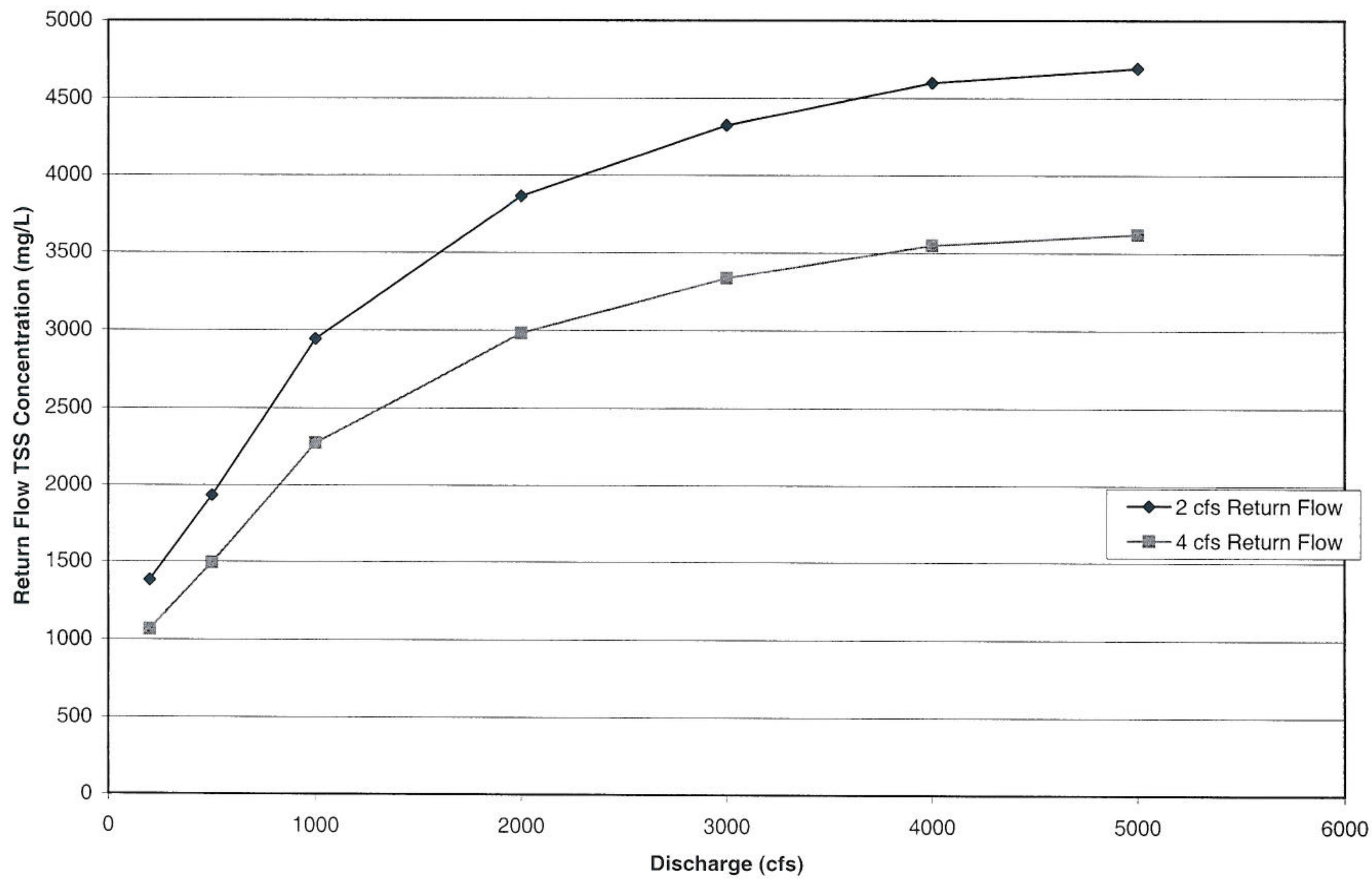
A.13. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
21 cfs Diversion Rate and 16% Sand Concentration



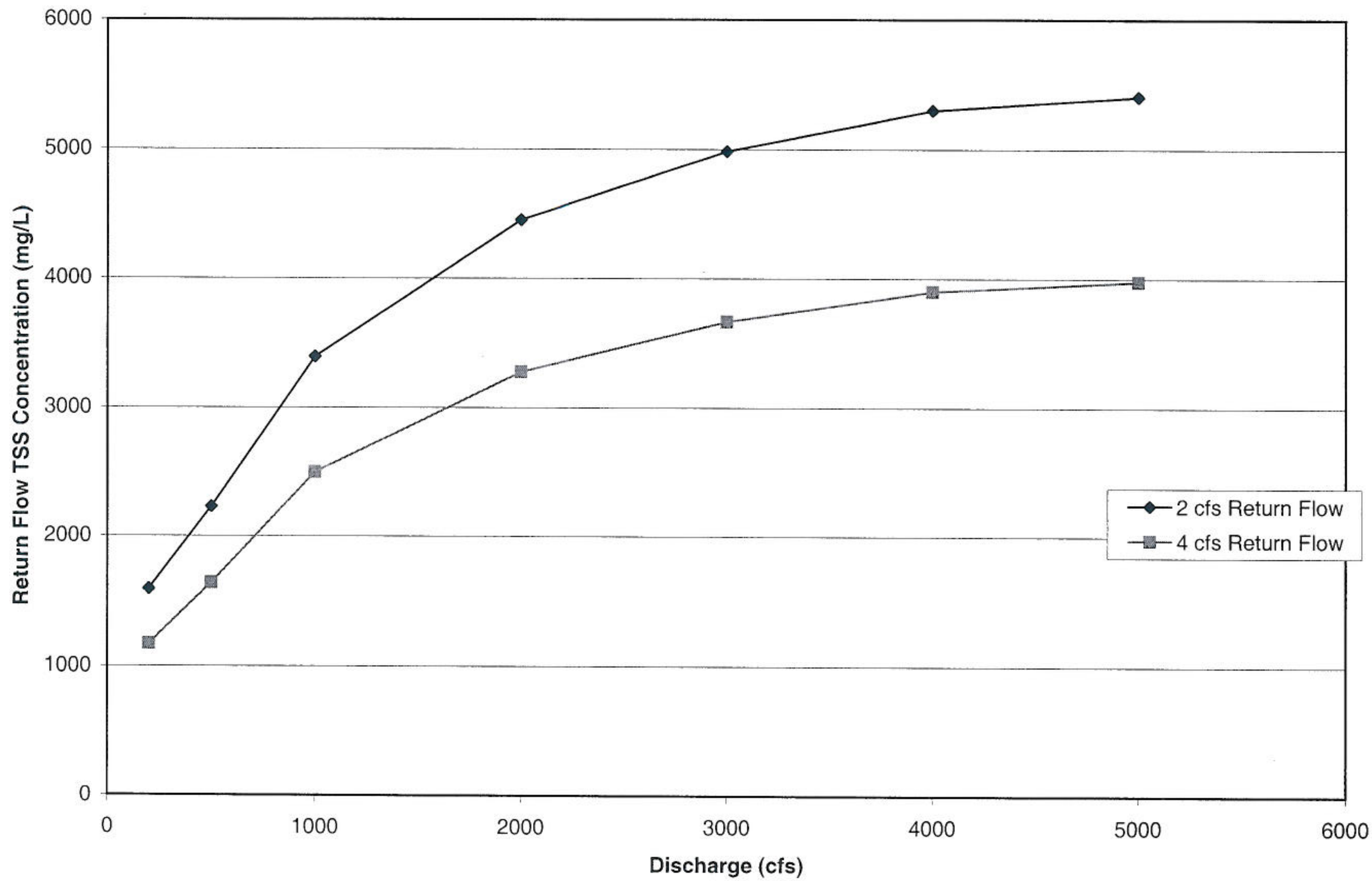
A.14. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
14 cfs Diversion Rate and 8% Sand Concentration



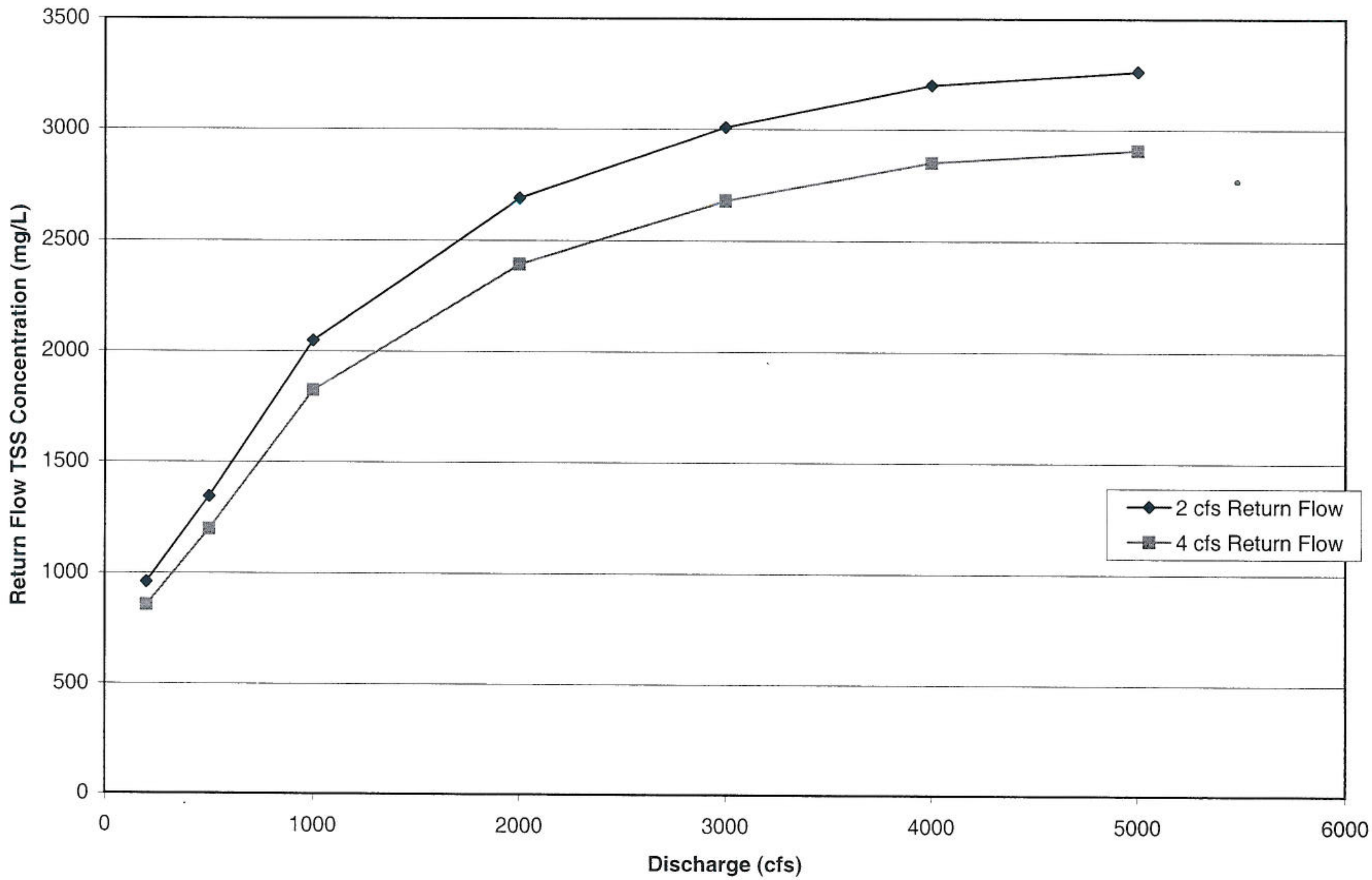
A.15. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
14 cfs Diversion Rate and 12% Sand Concentration



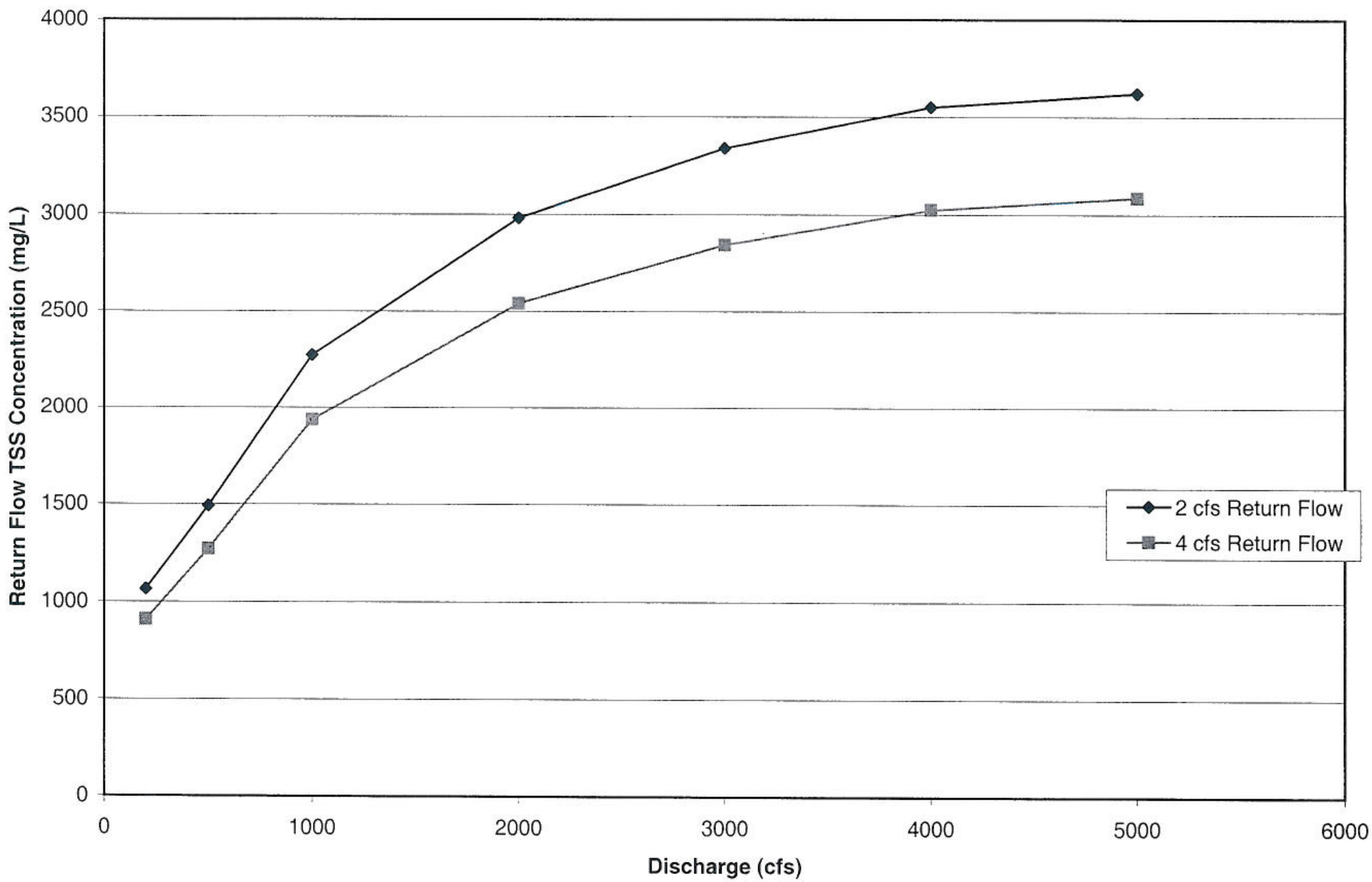
A.16. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
14 cfs Diversion Rate and 16% Sand Concentration



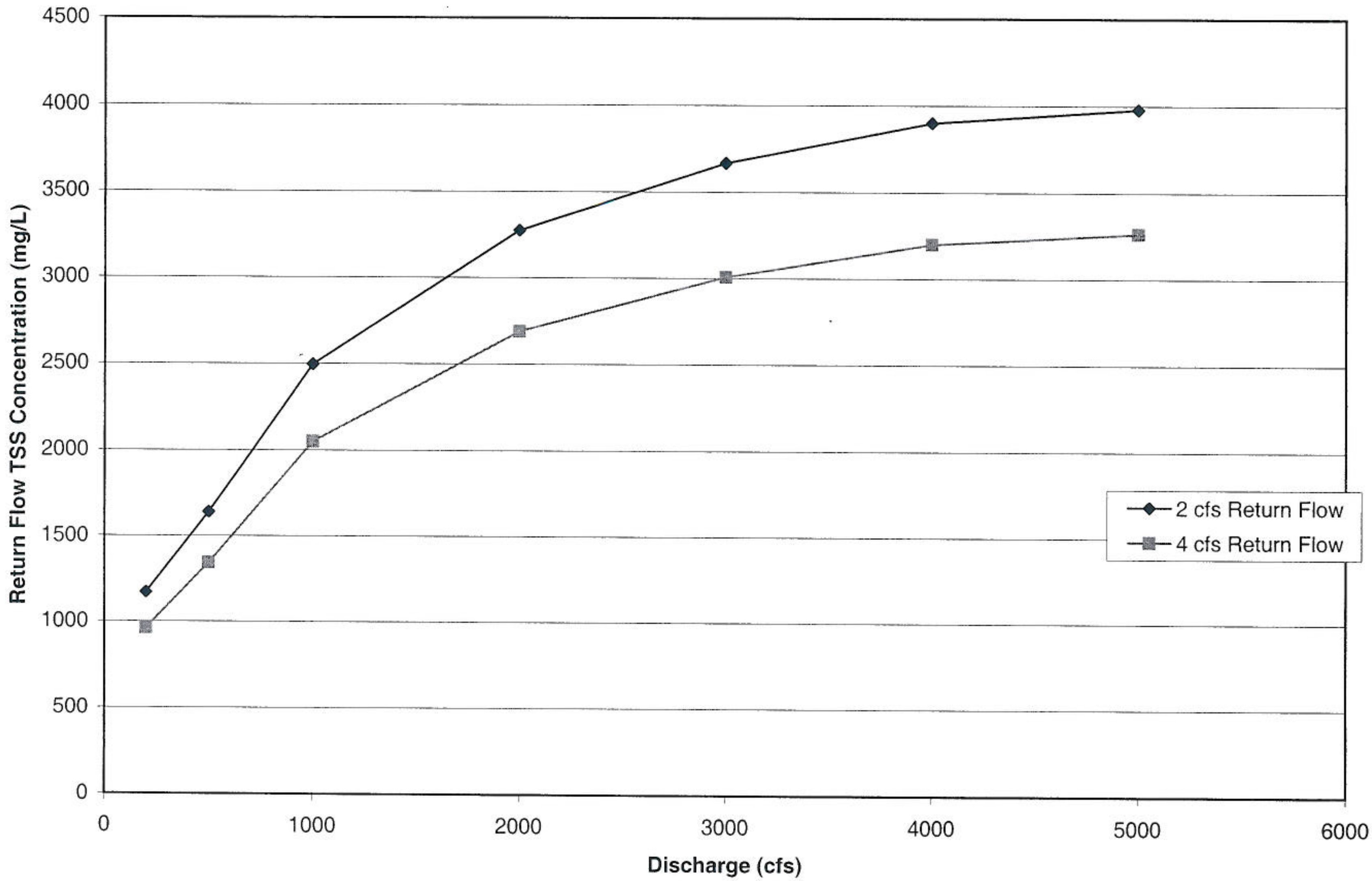
A.17. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
7 cfs Diversion Rate and 8% Sand Concentration



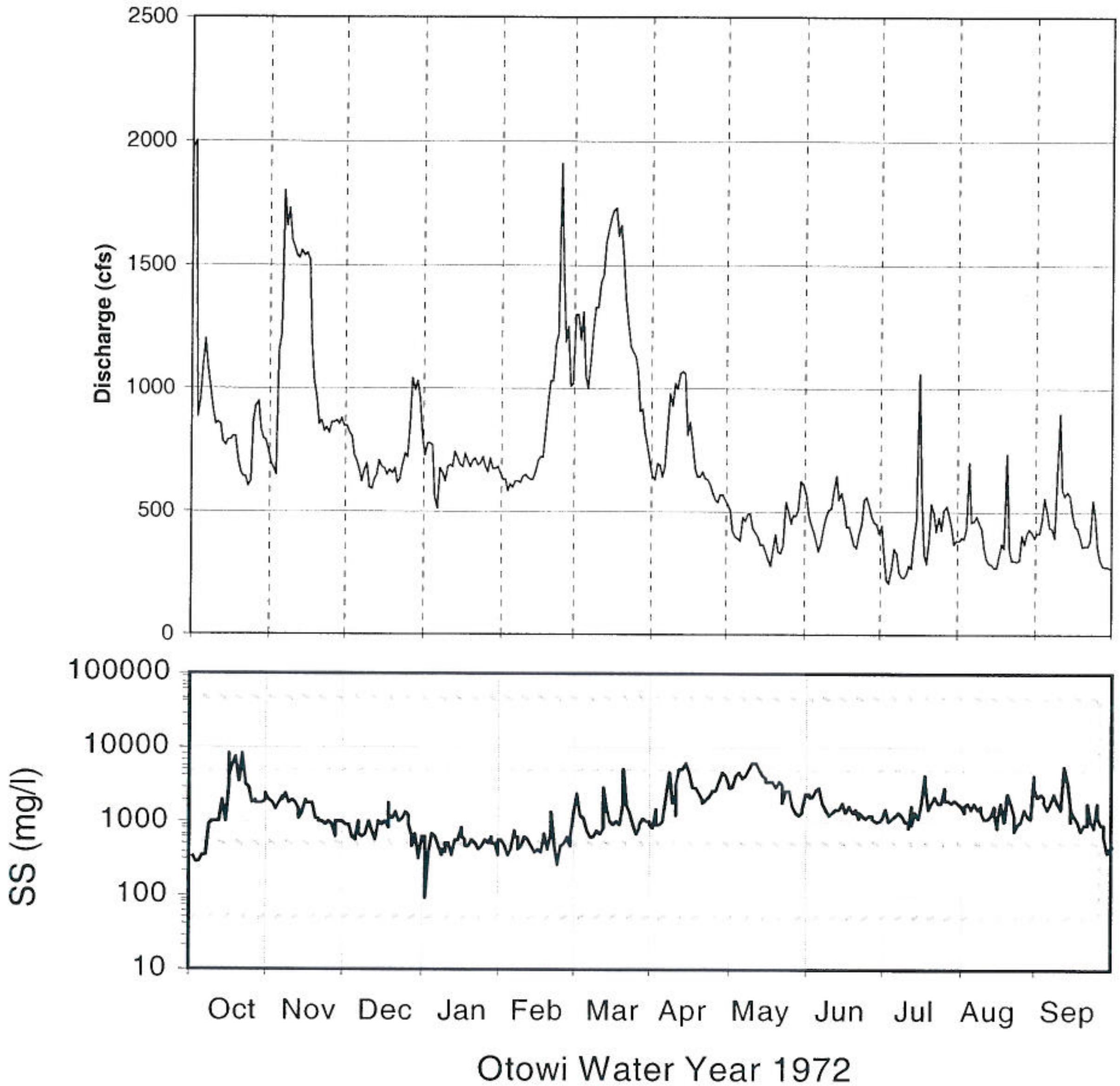
A.18. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
7 cfs Diversion Rate and 12% Sand Concentration



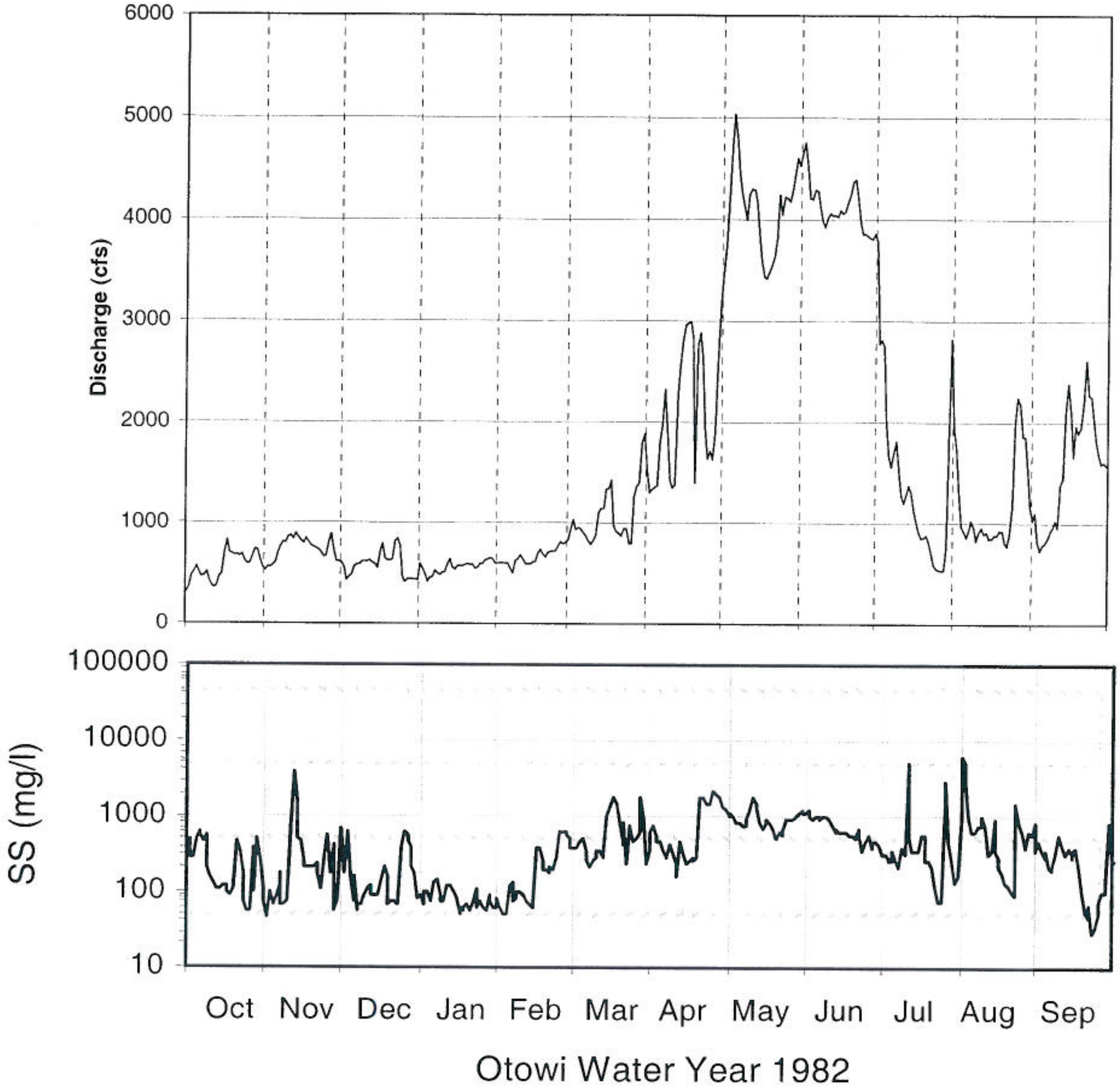
A.19. Return Flow TSS (mg/L) vs. Upstream Flow (cfs)
7 cfs Diversion Rate and 16% Sand Concentration



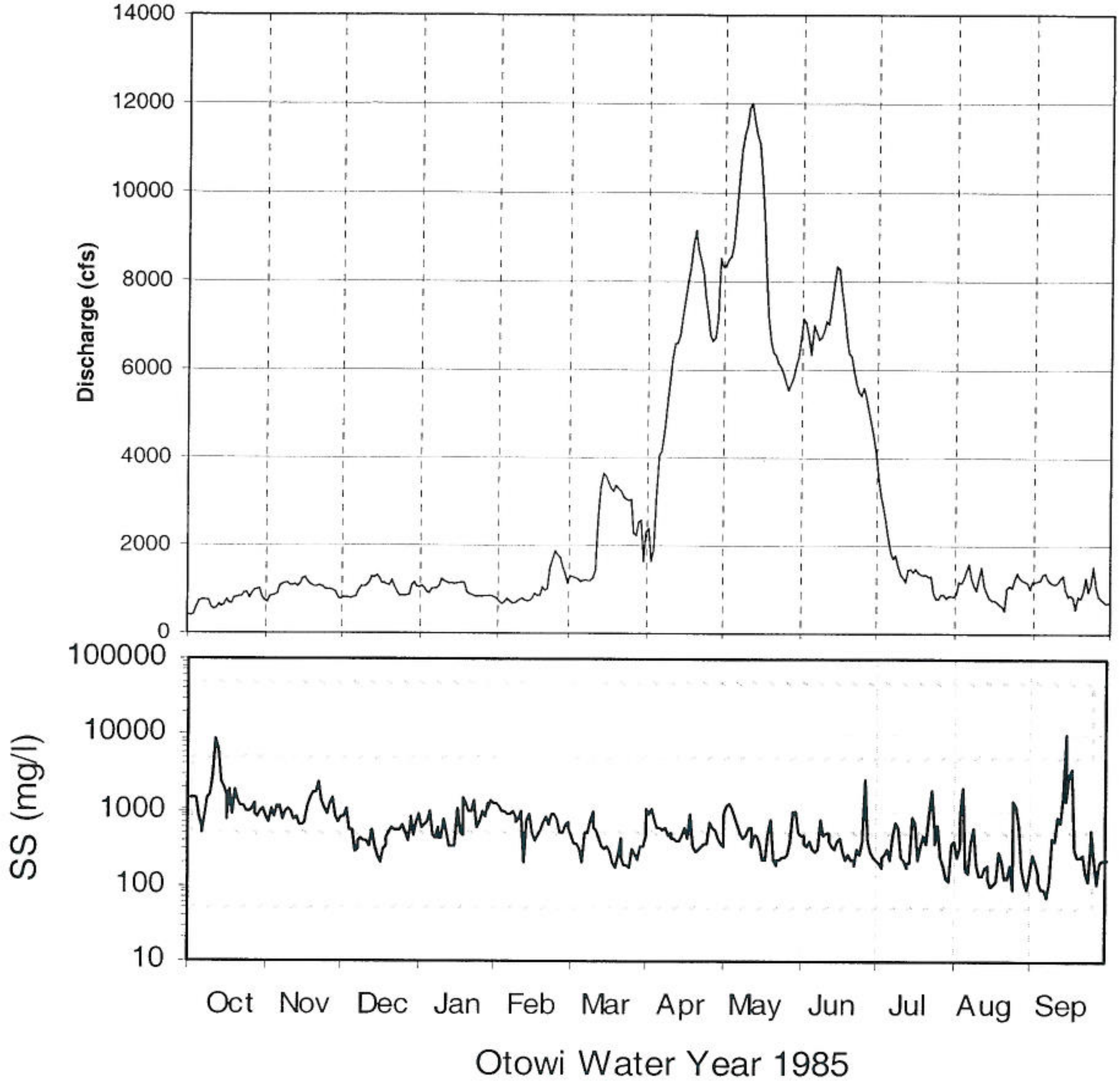
1972, 1982, and 1985 TSS Concentrations and Discharge Rates



1972 TSS Concentration and Discharge Rate (Low Flow Year)



1982 TSS Concentration and Discharge Rate (Average Flow Year)



1985 TSS Concentration and Discharge Rate (High Flow Year)

Appendix B.
Mass Balance Calculations Spreadsheet

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	200	200	200	200	200	200	200	200	200	200	200	200
2	Diversion Rate	Q_D [cfs]	28	28	28	28	28	28	21	21	21	21	21	21
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	750	750	750	750	750	750	750	750	750	750	750	750
6	Suspended Sand Concentration in River	S_s [mg/L]	60	90	120	60	90	120	60	90	120	60	90	120
7	Suspended Fines Concentration in River	S_F [mg/L]	690	660	630	690	660	630	690	660	630	690	660	630
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	339802	509703	679604	339802	509703	679604	339802	509703	679604	339802	509703	679604
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	5.4E+04	8.2E+04	1.1E+05	5.1E+04	7.6E+04	1.0E+05	4.2E+04	6.4E+04	8.5E+04	3.9E+04	5.9E+04	7.8E+04
10	Pumped Water Sand Load	S_sQ_D [mg/s]	47572	71358	95145	47572	71358	95145	35679	53519	71358	35679	53519	71358
11	Pumped Water Fines Load	S_FQ_D [mg/s]	547082	523295	499509	547082	523295	499509	410311	392472	374632	410311	392472	374632
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	690	660	630	690	660	630	690	660	630	690	660	630
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	6796	10194	13592	3398	5097	6796	6796	10194	13592	3398	5097	6796
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	78155	74756	71358	39077	37378	35679	78155	74756	71358	39077	37378	35679
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D + Q_d)$ [cfs]	168	168	168	170	170	170	175	175	175	177	177	177
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	3.57E+06	3.57E+06	3.57E+06	3.61E+06	3.61E+06	3.61E+06	3.72E+06	3.72E+06	3.72E+06	3.76E+06	3.76E+06	3.76E+06
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	1.33E+05	1.56E+05	1.80E+05	9.00E+04	1.14E+05	1.38E+05	1.21E+05	1.38E+05	1.56E+05	7.82E+04	9.60E+04	1.14E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	3.70E+06	3.72E+06	3.75E+06	3.70E+06	3.72E+06	3.75E+06	3.84E+06	3.86E+06	3.87E+06	3.84E+06	3.86E+06	3.87E+06
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	1170	1380	1590	1590	2010	2430	1065	1223	1380	1380	1695	2010
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	760	765	770	760	765	770	757	761	764	757	761	764
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	1.30%	1.95%	2.60%	1.30%	1.95%	2.60%	0.94%	1.41%	1.88%	0.94%	1.41%	1.88%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	200	200	200	200	200	200	200	200	200	200	200	200
2	Diversion Rate	Q_D [cfs]	14	14	14	14	14	14	7	7	7	7	7	7
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	750	750	750	750	750	750	750	750	750	750	750	750
6	Suspended Sand Concentration in River	S_s [mg/L]	60	90	120	60	90	120	60	90	120	60	90	120
7	Suspended Fines Concentration in River	S_F [mg/L]	690	660	630	690	660	630	690	660	630	690	660	630
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	339802	509703	679604	339802	509703	679604	339802	509703	679604	339802	509703	679604
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	3.1E+04	4.6E+04	6.1E+04	2.7E+04	4.1E+04	5.4E+04	1.9E+04	2.8E+04	3.7E+04	1.5E+04	2.3E+04	3.1E+04
10	Pumped Water Sand Load	S_sQ_D [mg/s]	23786	35679	47572	23786	35679	47572	11893	17840	23786	11893	17840	23786
11	Pumped Water Fines Load	S_FQ_D [mg/s]	273541	261648	249755	273541	261648	249755	136770	130824	124877	136770	130824	124877
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	690	660	630	690	660	630	690	660	630	690	660	630
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	6796	10194	13592	3398	5097	6796	6796	10194	13592	3398	5097	6796
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	78155	74756	71358	39077	37378	35679	78155	74756	71358	39077	37378	35679
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D + Q_d)$ [cfs]	182	182	182	184	184	184	189	189	189	191	191	191
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	3.87E+06	3.87E+06	3.87E+06	3.91E+06	3.91E+06	3.91E+06	4.01E+06	4.01E+06	4.01E+06	4.06E+06	4.06E+06	4.06E+06
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	1.09E+05	1.21E+05	1.33E+05	6.63E+04	7.82E+04	9.00E+04	9.68E+04	1.03E+05	1.09E+05	5.44E+04	6.03E+04	6.63E+04
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	3.97E+06	3.99E+06	4.00E+06	3.97E+06	3.99E+06	4.00E+06	4.11E+06	4.12E+06	4.12E+06	4.11E+06	4.12E+06	4.12E+06
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	960	1065	1170	1170	1380	1590	855	908	960	960	1065	1170
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	755	757	759	755	757	759	752	753	754	752	753	754
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.60%	0.90%	1.20%	0.60%	0.90%	1.20%	0.29%	0.44%	0.58%	0.29%	0.44%	0.58%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	500	500	500	500	500	500	500	500	500	500	500	500
2	Diversion Rate	Q_D [cfs]	28	28	28	28	28	28	21	21	21	21	21	21
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050
6	Suspended Sand Concentration in River	S_s [mg/L]	84	126	168	84	126	168	84	126	168	84	126	168
7	Suspended Fines Concentration in River	S_F [mg/L]	966	924	882	966	924	882	966	924	882	966	924	882
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	1189308	1783962	2378615	1189308	1783962	2378615	1189308	1783962	2378615	1189308	1783962	2378615
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	7.6E+04	1.1E+05	1.5E+05	7.1E+04	1.1E+05	1.4E+05	5.9E+04	8.9E+04	1.2E+05	5.5E+04	8.2E+04	1.1E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	66601	99902	133202	66601	99902	133202	49951	74926	99902	49951	74926	99902
11	Pumped Water Fines Load	S_FQ_D [mg/s]	765914	732614	699313	765914	732614	699313	574436	549460	524485	574436	549460	524485
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	966	924	882	966	924	882	966	924	882	966	924	882
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	9514	14272	19029	4757	7136	9514	9514	14272	19029	4757	7136	9514
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	109416	104659	99902	54708	52330	49951	109416	104659	99902	54708	52330	49951
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D+Q_d)$ [cfs]	468	468	468	470	470	470	475	475	475	477	477	477
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	1.39E+07	1.39E+07	1.39E+07	1.40E+07	1.40E+07	1.40E+07	1.41E+07	1.41E+07	1.41E+07	1.42E+07	1.42E+07	1.42E+07
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	1.86E+05	2.19E+05	2.52E+05	1.26E+05	1.59E+05	1.93E+05	1.69E+05	1.94E+05	2.19E+05	1.09E+05	1.34E+05	1.59E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	1.41E+07	1.41E+07	1.42E+07	1.41E+07	1.41E+07	1.42E+07	1.43E+07	1.43E+07	1.43E+07	1.43E+07	1.43E+07	1.43E+07
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	1638	1932	2226	2226	2814	3402	1491	1712	1932	1932	2373	2814
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	1055	1057	1060	1055	1057	1060	1054	1056	1057	1054	1056	1057
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.47%	0.71%	0.95%	0.47%	0.71%	0.95%	0.35%	0.53%	0.70%	0.35%	0.53%	0.70%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	500	500	500	500	500	500	500	500	500	500	500	500
2	Diversion Rate	Q_D [cfs]	14	14	14	14	14	14	7	7	7	7	7	7
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050
6	Suspended Sand Concentration in River	S_s [mg/L]	84	126	168	84	126	168	84	126	168	84	126	168
7	Suspended Fines Concentration in River	S_F [mg/L]	966	924	882	966	924	882	966	924	882	966	924	882
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	1189308	1783962	2378615	1189308	1783962	2378615	1189308	1783962	2378615	1189308	1783962	2378615
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	4.3E+04	6.4E+04	8.6E+04	3.8E+04	5.7E+04	7.6E+04	2.6E+04	3.9E+04	5.2E+04	2.1E+04	3.2E+04	4.3E+04
10	Pumped Water Sand Load	S_sQ_D [mg/s]	33301	49951	66601	33301	49951	66601	16650	24975	33301	16650	24975	33301
11	Pumped Water Fines Load	S_FQ_D [mg/s]	382957	366307	349656	382957	366307	349656	191479	183153	174828	191479	183153	174828
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	966	924	882	966	924	882	966	924	882	966	924	882
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	9514	14272	19029	4757	7136	9514	9514	14272	19029	4757	7136	9514
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	109416	104659	99902	54708	52330	49951	109416	104659	99902	54708	52330	49951
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D, Q_d)$ [cfs]	482	482	482	484	484	484	489	489	489	491	491	491
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	1.43E+07	1.43E+07	1.43E+07	1.44E+07	1.44E+07	1.44E+07	1.45E+07	1.45E+07	1.45E+07	1.46E+07	1.46E+07	1.46E+07
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	1.52E+05	1.69E+05	1.86E+05	9.28E+04	1.09E+05	1.26E+05	1.36E+05	1.44E+05	1.52E+05	7.61E+04	8.44E+04	9.28E+04
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.47E+07	1.47E+07	1.47E+07	1.47E+07	1.47E+07	1.47E+07
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	1344	1491	1638	1638	1932	2226	1197	1271	1344	1344	1491	1638
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	1052	1054	1055	1052	1054	1055	1051	1052	1052	1051	1052	1052
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.23%	0.35%	0.46%	0.23%	0.35%	0.46%	0.11%	0.17%	0.23%	0.11%	0.17%	0.23%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
2	Diversion Rate	Q_D [cfs]	28	28	28	28	28	28	21	21	21	21	21	21
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
6	Suspended Sand Concentration in River	S_s [mg/L]	128	192	256	128	192	256	128	192	256	128	192	256
7	Suspended Fines Concentration in River	S_F [mg/L]	1472	1408	1344	1472	1408	1344	1472	1408	1344	1472	1408	1344
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	3624557	5436835	7249114	3624557	5436835	7249114	3624557	5436835	7249114	3624557	5436835	7249114
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	1.2E+05	1.7E+05	2.3E+05	1.1E+05	1.6E+05	2.2E+05	9.1E+04	1.4E+05	1.8E+05	8.3E+04	1.3E+05	1.7E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	101488	152231	202975	101488	152231	202975	76116	114174	152231	76116	114174	152231
11	Pumped Water Fines Load	S_FQ_D [mg/s]	1167107	1116363	1065620	1167107	1116363	1065620	875330	837273	799215	875330	837273	799215
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	1472	1408	1344	1472	1408	1344	1472	1408	1344	1472	1408	1344
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	14498	21747	28996	7249	10874	14498	14498	21747	28996	7249	10874	14498
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	166730	159480	152231	83365	79740	76116	166730	159480	152231	83365	79740	76116
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D + Q_d)$ [cfs]	968	968	968	970	970	970	975	975	975	977	977	977
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	4.39E+07	4.39E+07	4.39E+07	4.39E+07	4.39E+07	4.39E+07	4.42E+07	4.42E+07	4.42E+07	4.43E+07	4.43E+07	4.43E+07
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	2.83E+05	3.33E+05	3.84E+05	1.92E+05	2.43E+05	2.94E+05	2.57E+05	2.95E+05	3.33E+05	1.67E+05	2.05E+05	2.43E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	4.41E+07	4.42E+07	4.42E+07	4.41E+07	4.42E+07	4.42E+07	4.44E+07	4.45E+07	4.45E+07	4.44E+07	4.45E+07	4.45E+07
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	2496	2944	3392	3392	4288	5184	2272	2608	2944	2944	3616	4288
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	1604	1606	1607	1604	1606	1607	1603	1604	1605	1603	1604	1605
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.23%	0.35%	0.46%	0.23%	0.35%	0.46%	0.17%	0.26%	0.34%	0.17%	0.26%	0.34%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
2	Diversion Rate	Q_D [cfs]	14	14	14	14	14	14	7	7	7	7	7	7
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
6	Suspended Sand Concentration in River	S_s [mg/L]	128	192	256	128	192	256	128	192	256	128	192	256
7	Suspended Fines Concentration in River	S_F [mg/L]	1472	1408	1344	1472	1408	1344	1472	1408	1344	1472	1408	1344
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	3624557	5436835	7249114	3624557	5436835	7249114	3624557	5436835	7249114	3624557	5436835	7249114
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	6.5E+04	9.8E+04	1.3E+05	5.8E+04	8.7E+04	1.2E+05	4.0E+04	6.0E+04	8.0E+04	3.3E+04	4.9E+04	6.5E+04
10	Pumped Water Sand Load	S_sQ_D [mg/s]	50744	76116	101488	50744	76116	101488	25372	38058	50744	25372	38058	50744
11	Pumped Water Fines Load	S_FQ_D [mg/s]	583554	558182	532810	583554	558182	532810	291777	279091	266405	291777	279091	266405
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	1472	1408	1344	1472	1408	1344	1472	1408	1344	1472	1408	1344
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	14498	21747	28996	7249	10874	14498	14498	21747	28996	7249	10874	14498
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	166730	159480	152231	83365	79740	76116	166730	159480	152231	83365	79740	76116
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_{D*}Q_d)$ [cfs]	982	982	982	984	984	984	989	989	989	991	991	991
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	4.45E+07	4.45E+07	4.45E+07	4.46E+07	4.46E+07	4.46E+07	4.48E+07	4.48E+07	4.48E+07	4.49E+07	4.49E+07	4.49E+07
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	2.32E+05	2.57E+05	2.83E+05	1.41E+05	1.67E+05	1.92E+05	2.07E+05	2.19E+05	2.32E+05	1.16E+05	1.29E+05	1.41E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	4.47E+07	4.47E+07	4.48E+07	4.47E+07	4.47E+07	4.48E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07	4.50E+07
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	2048	2272	2496	2496	2944	3392	1824	1936	2048	2048	2272	2496
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	1602	1603	1604	1602	1603	1604	1601	1601	1602	1601	1601	1602
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.11%	0.17%	0.23%	0.11%	0.17%	0.23%	0.06%	0.08%	0.11%	0.06%	0.08%	0.11%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
2	Diversion Rate	Q_D [cfs]	28	28	28	28	28	28	21	21	21	21	21	21
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
6	Suspended Sand Concentration in River	S_s [mg/L]	168	252	336	168	252	336	168	252	336	168	252	336
7	Suspended Fines Concentration in River	S_F [mg/L]	1932	1848	1764	1932	1848	1764	1932	1848	1764	1932	1848	1764
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	9514462	14271692	19028923	9514462	14271692	19028923	9514462	14271692	19028923	9514462	14271692	19028923
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	1.5E+05	2.3E+05	3.0E+05	1.4E+05	2.1E+05	2.9E+05	1.2E+05	1.8E+05	2.4E+05	1.1E+05	1.6E+05	2.2E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	133202	199804	266405	133202	199804	266405	99902	149853	199804	99902	149853	199804
11	Pumped Water Fines Load	S_FQ_D [mg/s]	1531828	1465227	1398626	1531828	1465227	1398626	1148871	1098920	1048969	1148871	1098920	1048969
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	1932	1848	1764	1932	1848	1764	1932	1848	1764	1932	1848	1764
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	19029	28543	38058	9514	14272	19029	19029	28543	38058	9514	14272	19029
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	218833	209318	199804	109416	104659	99902	218833	209318	199804	109416	104659	99902
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_{D+}Q_d)$ [cfs]	1968	1968	1968	1970	1970	1970	1975	1975	1975	1977	1977	1977
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	1.17E+08	1.17E+08	1.17E+08	1.17E+08	1.17E+08	1.17E+08	1.17E+08	1.17E+08	1.17E+08	1.18E+08	1.18E+08	1.18E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	3.71E+05	4.38E+05	5.04E+05	2.52E+05	3.19E+05	3.85E+05	3.38E+05	3.88E+05	4.38E+05	2.19E+05	2.69E+05	3.19E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	1.17E+08	1.17E+08	1.18E+08	1.17E+08	1.17E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	3276	3864	4452	4452	5628	6804	2982	3423	3864	3864	4746	5628
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2102	2104	2105	2102	2104	2105	2102	2103	2104	2102	2103	2104
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.114%	0.17%	0.23%	0.11%	0.17%	0.23%	0.085%	0.127%	0.17%	0.08%	0.13%	0.17%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
2	Diversion Rate	Q_D [cfs]	14	14	14	14	14	14	7	7	7	7	7	7
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
6	Suspended Sand Concentration in River	S_s [mg/L]	168	252	336	168	252	336	168	252	336	168	252	336
7	Suspended Fines Concentration in River	S_F [mg/L]	1932	1848	1764	1932	1848	1764	1932	1848	1764	1932	1848	1764
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	9514462	14271692	19028923	9514462	14271692	19028923	9514462	14271692	19028923	9514462	14271692	19028923
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	8.6E+04	1.3E+05	1.7E+05	7.6E+04	1.1E+05	1.5E+05	5.2E+04	7.8E+04	1.0E+05	4.3E+04	6.4E+04	8.6E+04
10	Pumped Water Sand Load	S_sQ_D [mg/s]	66601	99902	133202	66601	99902	133202	33301	49951	66601	33301	49951	66601
11	Pumped Water Fines Load	S_FQ_D [mg/s]	765914	732614	699313	765914	732614	699313	382957	366307	349656	382957	366307	349656
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	1932	1848	1764	1932	1848	1764	1932	1848	1764	1932	1848	1764
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	19029	28543	38058	9514	14272	19029	19029	28543	38058	9514	14272	19029
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	218833	209318	199804	109416	104659	99902	218833	209318	199804	109416	104659	99902
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D, Q_d)$ [cfs]	1982	1982	1982	1984	1984	1984	1989	1989	1989	1991	1991	1991
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	3.04E+05	3.38E+05	3.71E+05	1.86E+05	2.19E+05	2.52E+05	2.71E+05	2.88E+05	3.04E+05	1.52E+05	1.69E+05	1.86E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.18E+08	1.19E+08	1.19E+08	1.19E+08	1.19E+08	1.19E+08	1.19E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	2688	2982	3276	3276	3864	4452	2394	2541	2688	2688	2982	3276
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2101	2102	2102	2101	2102	2102	2101	2101	2101	2101	2101	2101
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.056%	0.085%	0.11%	0.06%	0.08%	0.11%	0.028%	0.042%	0.06%	0.03%	0.04%	0.06%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
2	Diversion Rate	Q_D [cfs]	28	28	28	28	28	28	21	21	21	21	21	21
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350
6	Suspended Sand Concentration in River	S_s [mg/L]	188	282	376	188	282	376	188	282	376	188	282	376
7	Suspended Fines Concentration in River	S_F [mg/L]	2162	2068	1974	2162	2068	1974	2162	2068	1974	2162	2068	1974
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	15970703	23956055	31941407	15970703	23956055	31941407	15970703	23956055	31941407	15970703	23956055	31941407
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	1.7E+05	2.6E+05	3.4E+05	1.6E+05	2.4E+05	3.2E+05	1.3E+05	2.0E+05	2.7E+05	1.2E+05	1.8E+05	2.4E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	149060	223590	298120	149060	223590	298120	111795	167692	223590	111795	167692	223590
11	Pumped Water Fines Load	S_FQ_D [mg/s]	1714189	1639659	1565129	1714189	1639659	1565129	1285642	1229744	1173847	1285642	1229744	1173847
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	2162	2068	1974	2162	2068	1974	2162	2068	1974	2162	2068	1974
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	21294	31941	42589	10647	15971	21294	21294	31941	42589	10647	15971	21294
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	244884	234237	223590	122442	117118	111795	244884	234237	223590	122442	117118	111795
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_{D+}Q_d)$ [cfs]	2968	2968	2968	2970	2970	2970	2975	2975	2975	2977	2977	2977
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	4.15E+05	4.90E+05	5.64E+05	2.82E+05	3.57E+05	4.31E+05	3.78E+05	4.34E+05	4.90E+05	2.45E+05	3.01E+05	3.57E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	3666	4324	4982	4982	6298	7614	3337	3831	4324	4324	5311	6298
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2352	2353	2354	2352	2353	2354	2351	2352	2353	2351	2352	2353
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.08%	0.11%	0.15%	0.08%	0.11%	0.15%	0.06%	0.08%	0.11%	0.06%	0.08%	0.11%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
2	Diversion Rate	Q_D [cfs]	14	14	14	14	14	14	7	7	7	7	7	7
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350
6	Suspended Sand Concentration in River	S_s [mg/L]	188	282	376	188	282	376	188	282	376	188	282	376
7	Suspended Fines Concentration in River	S_F [mg/L]	2162	2068	1974	2162	2068	1974	2162	2068	1974	2162	2068	1974
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	15970703	23956055	31941407	15970703	23956055	31941407	15970703	23956055	31941407	15970703	23956055	31941407
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	9.6E+04	1.4E+05	1.9E+05	8.5E+04	1.3E+05	1.7E+05	5.9E+04	8.8E+04	1.2E+05	4.8E+04	7.2E+04	9.6E+04
10	Pumped Water Sand Load	S_sQ_D [mg/s]	74530	111795	149060	74530	111795	149060	37265	55897	74530	37265	55897	74530
11	Pumped Water Fines Load	S_FQ_D [mg/s]	857094	819829	782564	857094	819829	782564	428547	409915	391282	428547	409915	391282
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	2162	2068	1974	2162	2068	1974	2162	2068	1974	2162	2068	1974
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	21294	31941	42589	10647	15971	21294	21294	31941	42589	10647	15971	21294
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	244884	234237	223590	122442	117118	111795	244884	234237	223590	122442	117118	111795
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_{D+}Q_d)$ [cfs]	2982	2982	2982	2984	2984	2984	2989	2989	2989	2991	2991	2991
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	1.98E+08	1.98E+08	1.98E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	3.41E+05	3.78E+05	4.15E+05	2.08E+05	2.45E+05	2.82E+05	3.03E+05	3.22E+05	3.41E+05	1.70E+05	1.89E+05	2.08E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08	1.99E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	3008	3337	3666	3666	4324	4982	2679	2844	3008	3008	3337	3666
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2351	2351	2352	2351	2351	2352	2350	2351	2351	2350	2351	2351
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.04%	0.06%	0.08%	0.04%	0.06%	0.08%	0.02%	0.03%	0.04%	0.02%	0.03%	0.04%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
2	Diversion Rate	Q_D [cfs]	28	28	28	28	28	28	21	21	21	21	21	21
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
6	Suspended Sand Concentration in River	S_s [mg/L]	200	300	400	200	300	400	200	300	400	200	300	400
7	Suspended Fines Concentration in River	S_F [mg/L]	2300	2200	2100	2300	2200	2100	2300	2200	2100	2300	2200	2100
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	22653480	33980220	45306960	22653480	33980220	45306960	22653480	33980220	45306960	22653480	33980220	45306960
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	1.8E+05	2.7E+05	3.6E+05	1.7E+05	2.5E+05	3.4E+05	1.4E+05	2.1E+05	2.8E+05	1.3E+05	2.0E+05	2.6E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	158574	237862	317149	158574	237862	317149	118931	178396	237862	118931	178396	237862
11	Pumped Water Fines Load	S_FQ_D [mg/s]	1823605	1744318	1665031	1823605	1744318	1665031	1367704	1308238	1248773	1367704	1308238	1248773
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	2300	2200	2100	2300	2200	2100	2300	2200	2100	2300	2200	2100
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	22653	33980	45307	11327	16990	22653	22653	33980	45307	11327	16990	22653
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	260515	249188	237862	130258	124594	118931	260515	249188	237862	130258	124594	118931
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D + Q_d)$ [cfs]	3968	3968	3968	3970	3970	3970	3975	3975	3975	3977	3977	3977
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	2.81E+08	2.81E+08	2.81E+08	2.81E+08	2.81E+08	2.81E+08	2.81E+08	2.81E+08	2.81E+08	2.82E+08	2.82E+08	2.82E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	4.42E+05	5.21E+05	6.00E+05	3.00E+05	3.79E+05	4.59E+05	4.02E+05	4.62E+05	5.21E+05	2.61E+05	3.20E+05	3.79E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	2.81E+08	2.81E+08	2.82E+08	2.81E+08	2.81E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	3900	4600	5300	5300	6700	8100	3550	4075	4600	4600	5650	6700
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2501	2502	2503	2501	2502	2503	2501	2502	2502	2501	2502	2502
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.06%	0.08%	0.11%	0.06%	0.08%	0.11%	0.04%	0.06%	0.08%	0.04%	0.06%	0.08%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
2	Diversion Rate	Q_D [cfs]	14	14	14	14	14	14	7	7	7	7	7	7
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
6	Suspended Sand Concentration in River	S_s [mg/L]	200	300	400	200	300	400	200	300	400	200	300	400
7	Suspended Fines Concentration in River	S_F [mg/L]	2300	2200	2100	2300	2200	2100	2300	2200	2100	2300	2200	2100
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	22653480	33980220	45306960	22653480	33980220	45306960	22653480	33980220	45306960	22653480	33980220	45306960
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	1.0E+05	1.5E+05	2.0E+05	9.1E+04	1.4E+05	1.8E+05	6.2E+04	9.3E+04	1.2E+05	5.1E+04	7.6E+04	1.0E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	79287	118931	158574	79287	118931	158574	39644	59465	79287	39644	59465	79287
11	Pumped Water Fines Load	S_FQ_D [mg/s]	911803	872159	832515	911803	872159	832515	455901	436079	416258	455901	436079	416258
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	2300	2200	2100	2300	2200	2100	2300	2200	2100	2300	2200	2100
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	22653	33980	45307	11327	16990	22653	22653	33980	45307	11327	16990	22653
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	260515	249188	237862	130258	124594	118931	260515	249188	237862	130258	124594	118931
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_{D+}Q_d)$ [cfs]	3982	3982	3982	3984	3984	3984	3989	3989	3989	3991	3991	3991
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.83E+08	2.83E+08	2.83E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	3.62E+05	4.02E+05	4.42E+05	2.21E+05	2.61E+05	3.00E+05	3.23E+05	3.43E+05	3.62E+05	1.81E+05	2.01E+05	2.21E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.82E+08	2.83E+08	2.83E+08	2.83E+08	2.83E+08	2.83E+08	2.83E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	3200	3550	3900	3900	4600	5300	2850	3025	3200	3200	3550	3900
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2501	2501	2501	2501	2501	2501	2500	2501	2501	2500	2501	2501
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.03%	0.04%	0.06%	0.03%	0.04%	0.06%	0.01%	0.02%	0.03%	0.01%	0.02%	0.03%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
2	Diversion Rate	Q_D [cfs]	28	28	28	28	28	28	21	21	21	21	21	21
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550
6	Suspended Sand Concentration in River	S_s [mg/L]	204	306	408	204	306	408	204	306	408	204	306	408
7	Suspended Fines Concentration in River	S_F [mg/L]	2346	2244	2142	2346	2244	2142	2346	2244	2142	2346	2244	2142
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	28883187	43324781	57766374	28883187	43324781	57766374	28883187	43324781	57766374	28883187	43324781	57766374
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	1.8E+05	2.8E+05	3.7E+05	1.7E+05	2.6E+05	3.5E+05	1.4E+05	2.2E+05	2.9E+05	1.3E+05	2.0E+05	2.7E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	161746	242619	323492	161746	242619	323492	121309	181964	242619	121309	181964	242619
11	Pumped Water Fines Load	S_FQ_D [mg/s]	1860077	1779204	1698331	1860077	1779204	1698331	1395058	1334403	1273749	1395058	1334403	1273749
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	2346	2244	2142	2346	2244	2142	2346	2244	2142	2346	2244	2142
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	23107	34660	46213	11553	17330	23107	23107	34660	46213	11553	17330	23107
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	265725	254172	242619	132863	127086	121309	265725	254172	242619	132863	127086	121309
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_{D+}Q_d)$ [cfs]	4968	4968	4968	4970	4970	4970	4975	4975	4975	4977	4977	4977
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	4.51E+05	5.31E+05	6.12E+05	3.06E+05	3.87E+05	4.68E+05	4.10E+05	4.71E+05	5.31E+05	2.66E+05	3.26E+05	3.87E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.59E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	3978	4692	5406	5406	6834	8262	3621	4157	4692	4692	5763	6834
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2551	2552	2552	2551	2552	2552	2551	2551	2552	2551	2551	2552
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.05%	0.07%	0.09%	0.05%	0.07%	0.09%	0.03%	0.05%	0.07%	0.03%	0.05%	0.07%

Mass Balance Calculations
Buckman Diversion Project

	Description	Calculation and Units												
1	Upstream flow	Q_R [cfs]	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
2	Diversion Rate	Q_D [cfs]	14	14	14	14	14	14	7	7	7	7	7	7
3	Diverted Carriage Water (returned)	Q_d [cfs]	4	4	4	2	2	2	4	4	4	2	2	2
4	Percentage Sand-Sized Particles (>0.25mm)	%	8%	12%	16%	8%	12%	16%	8%	12%	16%	8%	12%	16%
5	Total Suspended Sediment Concentration in River	S_{ST} [mg/L]	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550	2550
6	Suspended Sand Concentration in River	S_s [mg/L]	204	306	408	204	306	408	204	306	408	204	306	408
7	Suspended Fines Concentration in River	S_F [mg/L]	2346	2244	2142	2346	2244	2142	2346	2244	2142	2346	2244	2142
8	Sand Load in River	$S_s \times Q_R$ [mg/s]	28883187	43324781	57766374	28883187	43324781	57766374	28883187	43324781	57766374	28883187	43324781	57766374
9	Diversion Sand Load - Total Diversion	$S_s \times (Q_D + Q_d)$ [mg/s]	1.0E+05	1.6E+05	2.1E+05	9.2E+04	1.4E+05	1.8E+05	6.4E+04	9.5E+04	1.3E+05	5.2E+04	7.8E+04	1.0E+05
10	Pumped Water Sand Load	S_sQ_D [mg/s]	80873	121309	161746	80873	121309	161746	40436	60655	80873	40436	60655	80873
11	Pumped Water Fines Load	S_FQ_D [mg/s]	930039	889602	849166	930039	889602	849166	465019	444801	424583	465019	444801	424583
12	Pumped Water Fines Concentration	Same as in River S_F (mg/L)	2346	2244	2142	2346	2244	2142	2346	2244	2142	2346	2244	2142
13	Diverted Carriage Water Sand Load	S_sQ_d [mg/s]	23107	34660	46213	11553	17330	23107	23107	34660	46213	11553	17330	23107
14	Diverted Carriage Water Fines Load	S_FQ_d [mg/s]	265725	254172	242619	132863	127086	121309	265725	254172	242619	132863	127086	121309
15	Bypass River Flow	$Q_{BF} = Q_R - (Q_D + Q_d)$ [cfs]	4982	4982	4982	4984	4984	4984	4989	4989	4989	4991	4991	4991
16	Bypass River Flow TSS Load	$Q_{BF}S_{ST}$ [mg/s]	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08
17	Return Flow TSS Load	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)$ [mg/s]	3.70E+05	4.10E+05	4.51E+05	2.25E+05	2.66E+05	3.06E+05	3.29E+05	3.49E+05	3.70E+05	1.85E+05	2.05E+05	2.25E+05
18	Total Downstream TSS Load	$S_{DST} = (S_sQ_D)+(S_sQ_d)+(Q_dS_F)+(Q_{BF}S_{ST})$ [mg/s]	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.60E+08	3.61E+08	3.61E+08	3.61E+08	3.61E+08	3.61E+08	3.61E+08
19	Return Flow TSS Concentration	$(S_sQ_D)+(S_sQ_d)+(Q_dS_F)/(Q_d)$ [mg/L]	3264	3621	3978	3978	4692	5406	2907	3086	3264	3264	3621	3978
20	Downstream TSS Concentration	$TSS_{DS} = S_{DST}/(Q_d+Q_{BF})$ [mg/L]	2551	2551	2551	2551	2551	2551	2550	2550	2551	2550	2550	2551
21	Increase in TSS Concentration Downstream	$(TSS_{DS}-S_{ST})/S_{ST}$ [%]	0.02%	0.03%	0.04%	0.02%	0.03%	0.04%	0.01%	0.02%	0.02%	0.01%	0.02%	0.02%